Effect of Certain Pesticides on the Germination and Growth of Wheat and Barley Plants Alongwith A Study of the Chemical Control of Termites

ABSTRACT

THESIS SUBMITTED FOR THE DEGREE OF

Doctor of Philosophy

IN

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BY

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DEPARTMENT OF ZOOLOGY
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ABSTRACT

Termites, (*Odontotermes obesus* (Rambur) and *Microtermes obesi* Holmgren still continue to occupy their supremacy in causing recurring losses to wheat and barley crops and limit their yields in Rajasthan and other States of India particularly where rainfed or tube-well irrigated crops are grown. The relevant approaches for termite control include pre-sowing soil application, seed treatment and post-sowing treatment with insecticides besides the extermination of mound-building termite colonies by chemical application. Of these, seed treatment occupies a special niche in view of its cheapness, convenience in handling and necessity of the chemical in meagre quantities. But before any seed treatment method is recommended it is a peremptory requisite to have an adequate knowledge of the pesticide and seed relationship - that the effective dose against the pest must not jeopardise the germination of seed.

The arrival of new compounds in the last decade necessitated their evaluation for the control of termites through seed treatment. The dearth of information on these aspects in the literature from regions agro-climatically poles apart from Rajasthan

made it imperative to undertake studies on the efficacy of certain pesticidal applications on the control of termites in wheat and barley crops after carefully scanning their effects on the germination and plant growth to evolve tenable control measures.

The studies were conducted under laboratory, green-house and field conditions mainly at the Agricultural Research Station, Durgapura, Jaipur (Mohan Lal Sukhadia University, Udaipur, Rajasthan) from 1978-79 to 1980-81.

Tests conducted on the relative adherence of dry pesticidal powders indicated a differential pattern of adherence to wheat and barley seed, with relatively more adherence on the latter. The actual coating of the powder was in all cases lesser than their application rates.

In the test of dry adherence of pesticidal powders at three different rates for wheat and barley, although an increased retention was observed with the rise in the application rates, no linear pattern was observed. Two per cent methyl cellulose solution gave the maximum loading followed by gum arabic and soluble starch for BHC and chlordane dust at two application rates.

The germination of wheat and barley seed in green-house and microplot trials was observed to be governed by the specificity of the pesticide, dosage, formulation, seed type and the testing conditions. In case of wheat seed treatment with aldrin, endosulfan, lindane dusts and larvin wettable powder at 2 kg dry, 2 and 4 kg with sticker and emulsifiable concentrates of aldrin, endosulfan, isophenphos, malathion + DDT + BHC at dosage of 80, 120 and 160 g a.i. did not have any inhibitory effect on germination, while the rest adversely affected germination. However, in the case of barley no adverse effect on germination was observed in all the treatments except where carbaryl, BHC and landrin wettable powders were used with sticker and lindane emulsifiable concentrate at the rate of 80 to 200 g a.i. was used. At comparable dosages, powders were more safer than emulsifiable formulations as regards germination. Further, the barley seed was found to be more tolerant than wheat to the different dosages of the tested pesticides.

The study gives the precise and detailed description of seedling toxicity symptoms following insecticidal application for the first time for certain new compounds.

The observations on the mean emergence period of wheat and barley subsequent to seed treatment by powder and emulsifiable formulation at different dosages in green-house tests revealed that in case of emulsifiable formulations the period of emergence was delayed in increasing rate of application. As regards powders, the same trend was observed with BHC 5 per cent, heptachlor 5 per cent, malathion + DDT + BHC (3:3:2) per cent, isophenphos + TMTD (30:10) per cent and larvin 75 per cent wettable powder in case of wheat. In case of barley, only BHC and landrin 50 per cent wettable powder (all three dosages) and carbaryl 50 per cent wettable powder at 2 and 4 kg dosages with sticker delayed emergence while the rest of the treatments did not interfere with germination.

The effect of pesticidal seed treatment in wheat and barley using the criteria of seedling height, seedling dry weight, germination and productive tillering indicated the safe dosages of some of the tested pesticides. The observations indicated the order of preference in favour of dry seedling weight as compared to top height, between the two parameters of plant growth used as indicators to assess the toxicity of compounds under green-house tests.

The trials conducted for two seasons for the control of termites in wheat and barley under field conditions by pesticidal powders (with or without stickers) and emulsions, taking into account the germination, plant and tiller damage, revealed the superiority of all the treatments except BPMC and carboxin over control. In both the crops, the powder and emulsifiable formulations of aldrin besides endosulfan emulsion proved efficacious. Further experiments on the application of insecticides through irrigation water to the standing wheat crop indicated the effectiveness of aldrin, heptachlor and lindane at the rate of 400 g a.i. and chlordane at the rate of 600 g a.i. in controlling termite infestation. The attempts to destroy the colony of mound inhabiting termites, *Odontotermes obesus* revealed that drenching of aldrin 30 emulsifiable concentrate at the rate of 20 ml and heptachlor 20 emulsifiable concentrate at the rate of 30 ml added to 30 litres of water per cubic metre of mound volume gave the best results.

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C E R T I F I C A T E

This is to certify that this thesis entitled "Effect of certain pesticides on the germination and growth of wheat and barley plants together with a study on the chemical control of termites" describes the original work done by Mr. RAIS MOHAMMAD KHAN under our supervision and is suitable for submission for the award of the degree of DOCTOR OF PHILOSOPHY of the Aligarh Muslim University, Aligarh, U.P.

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C O N T E N T S

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CHAPTER I

I N T R O D U C T I O N

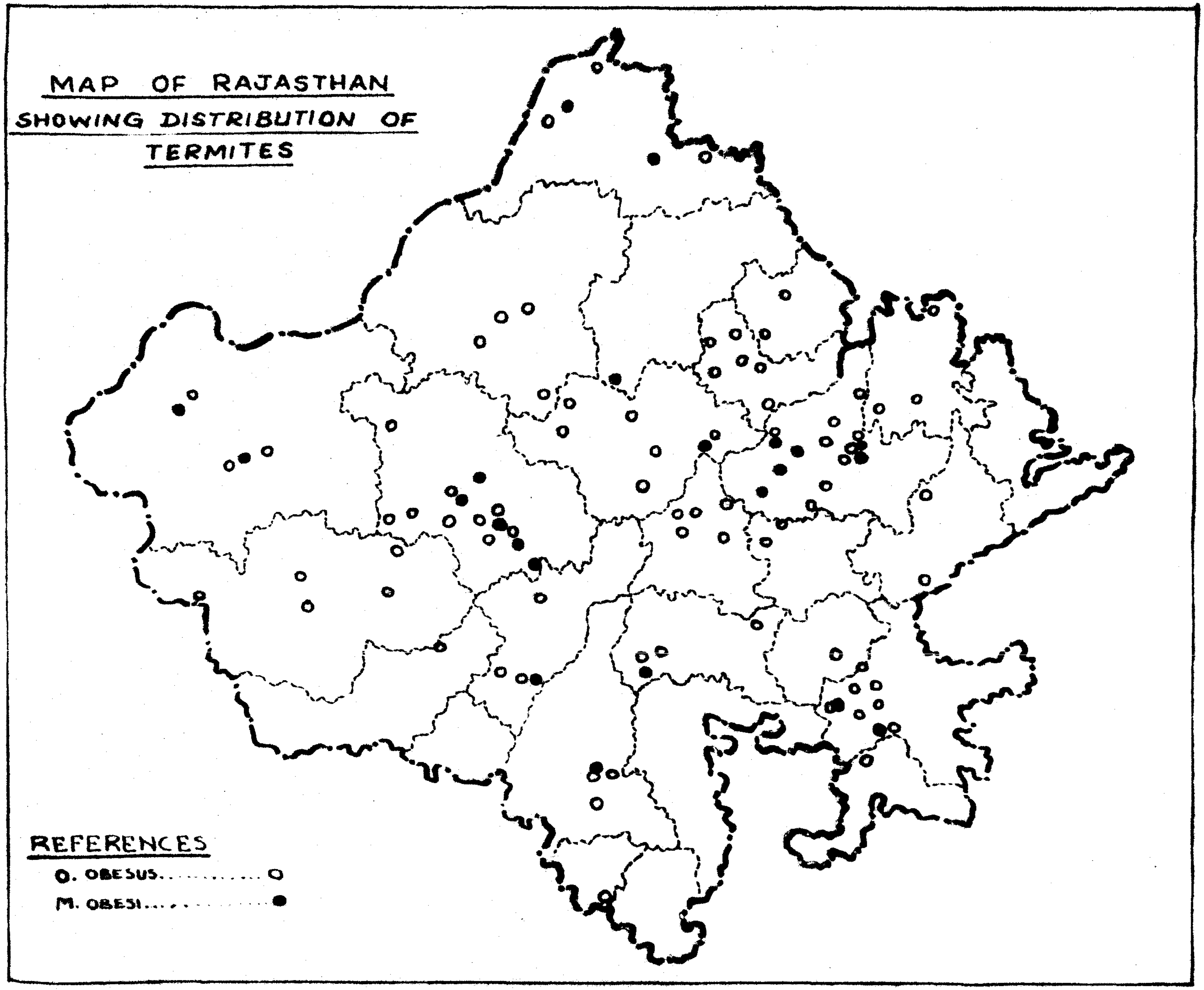
Increasing cereal production at a faster rate is a matter of cardinal importance for the ever increasing human population. It is a sullen irony in our success of the 'green revolution' that pest problems have accentuated with the introduction of high yielding varieties and improved agronomical practices in India. Besides the looming threat by the new pests, termites still continue to occupy a unique niche among damaging pests due to their fairly consistent appearance and inherent potentiality of causing heavy losses to the crops. Hence, termite infestation to wheat and barley crops stands as number one among the limiting factors in obtaining their optimum yields. In Rajasthan the two outrageous species of termites, Odontotermes obesus (Rambur) and Microtermes obesi Holmgren are widely distributed (Map 1) which are mainly responsible for ravages to wheat and barley crops. Both these species are subterranean in habit with the exception that the former can also build mounds.

According to the estimated data* for 1980-81 season for Rajasthan, wheat was grown in 16.31 lac hectares

* Final forecast issued by the Board of Revenue, Government of Rajasthan, Ajmer for 1980-81.

MAP 1

Map of Rajasthan showing
distribution of termites

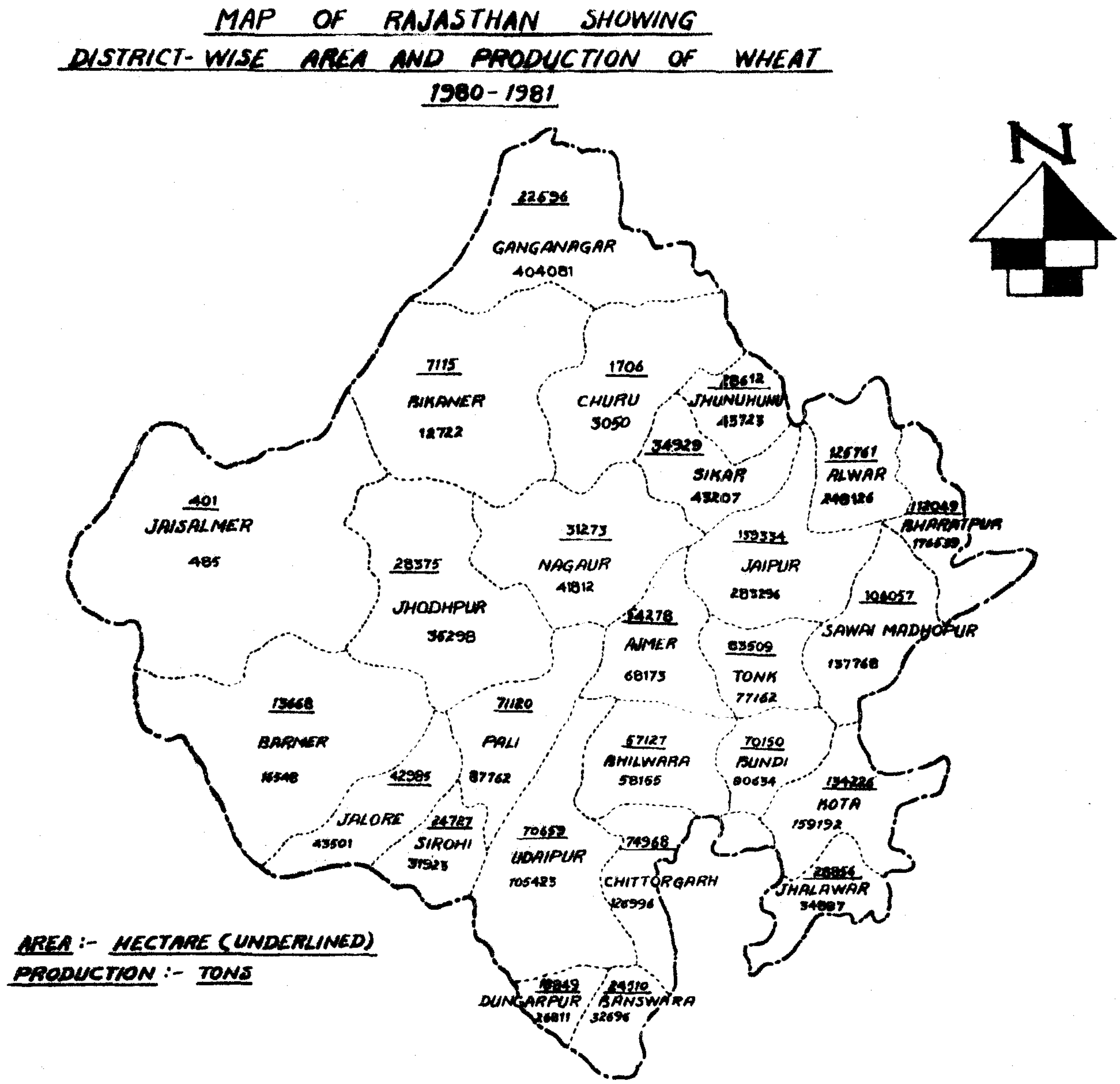

MAP OF RAJASTHAN
SHOWING DISTRIBUTION OF
TERMITES
REFERENCES
O. OBESUS.
M. OBESI.

with a production of 23.89 lac tons and barley covered an area of 4.09 lac hectares with a production of 5.17 lac tons (Map 2 and 3). It is estimated that nearly 14.84 and 26.16 per cent wheat and barley crops, respectively, were grown in unirrigated tract during 1980-81. It is believed that crops subject to water stress are usually more prone to termite infestation than those with ample supply (Peshwani and Katiyar, 1972; Sands, 1977). The irrigated wheat and barley crops are mainly commanded by tube-wells where the frequency of irrigation generally remains less for certain unavoidable circumstances in Rajasthan. The crops thus face water stress due to rapid loss of moisture in lighter soils which made them more vulnerable to termite attack. They cut and eat away the underground parts of the plant resulting in withering, yellowing and finally the death of the plant which can be easily pulled off (Plate 1; Fig. 1). Normally both these crops suffer maximum damage in the early stage by death of the seedlings or young tillers and during the earing phase as a result of which the ear-heads become chaffy or bear shrivelled grains (Plate 1; Fig. 2).

Information on the losses caused by termites to wheat crop are available from different reports. Hussain (1935) put the loss from 6 to 25 per cent.

MAP 2

Map of Rajasthan showing
district-wise area and
production of wheat 1980-1981


MAP OF RAJASTHAN SHOWING
DISTRICT- WISE AREA AND PRODUCTION OF WHEAT
1980 - 1981
N
22696
GANGANAGAR
404081
7115
BIKANER
12722
1706
CHURU
3050
28612
JHUNUHUNU
45723
34929
SIKAR
43207
125761
ALWAR
248126
112049
BHARATPUR
176539
401
JAISALMER
485
31273
NAGAUR
41812
159334
JAIPUR
283296
28375
JHODHPUR
36298
54278
AJMER
68173
108057
SAWAI MADHOPUR
137768
63509
TONK
77162
13668
BARMER
16548
71120
PALI
87762
57127
BHILWARA
58165
70150
BUNDI
80634
134226
KOTA
159192
42985
JALORE
43501
24787
SIROHI
31925
70659
UDAIPUR
105425
74968
CHITTORGARH
126996
28854
JHALAWAR
34887
18849
DUNGARPUR
26811
24510
BANSWARA
32696
AREA :- HECTARE (UNDERLINED)
PRODUCTION :- TONS

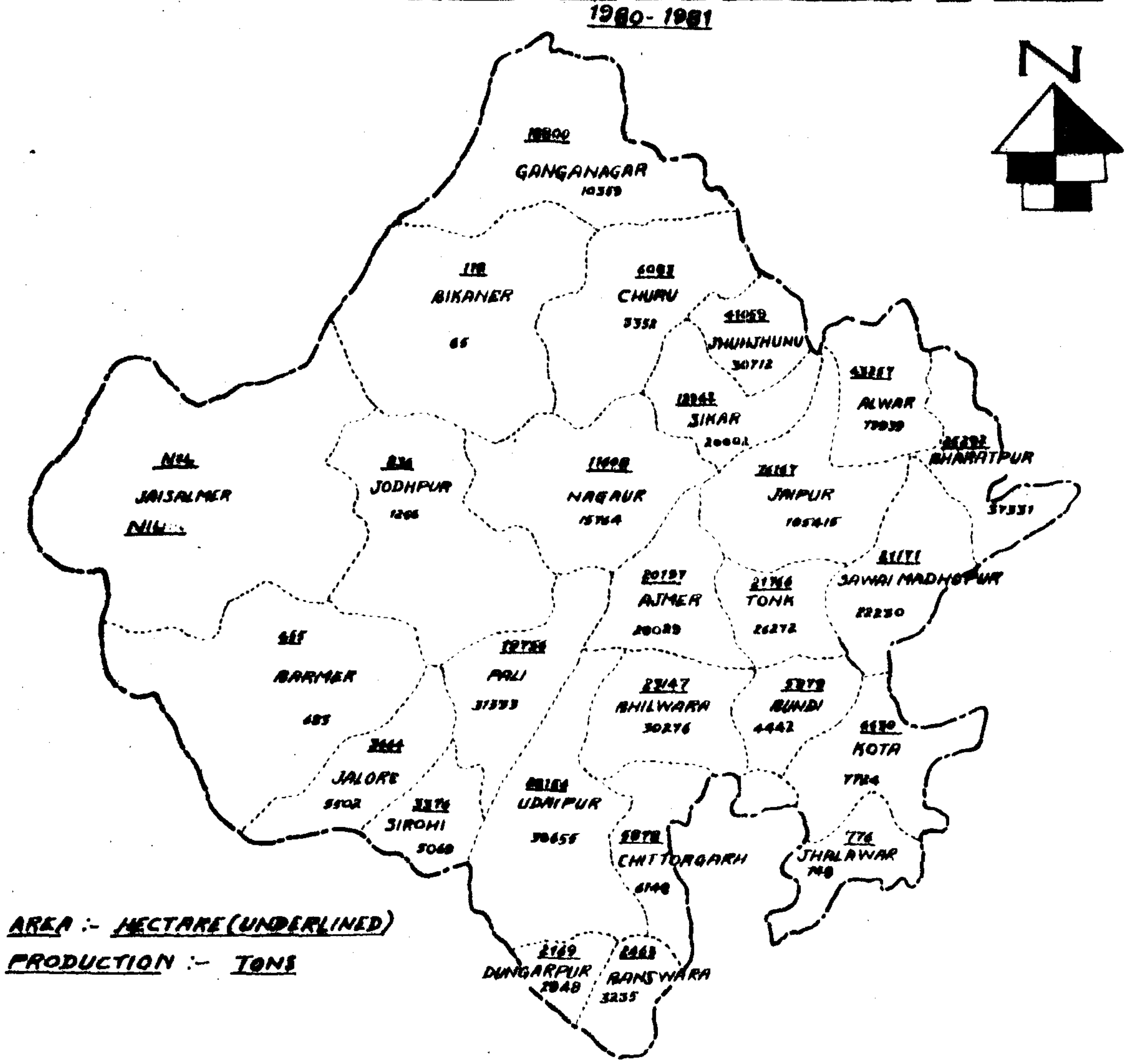
MAP 3

Map of Rajasthan showing district-wise area and production of barley 1980-1981

MAP OF RAJASTHAN SHOWING

DISTRICT-WISE AREA AND PRODUCTION OF BARLEY

1980-1981



AREA :- HECTARE (UNDERLINED)

PRODUCTION :- TONS

PLATE I

Fig. 1 Termite damaged plants

Fig. 2 Grains from healthy and damaged plants

PLATE I

FIG. 1

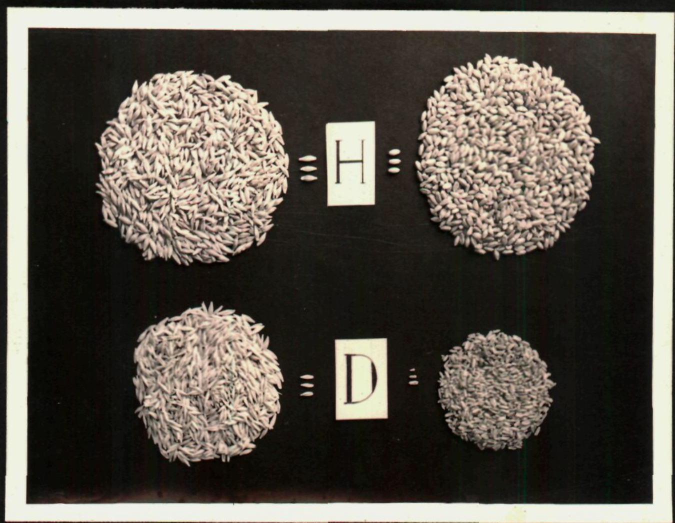


FIG. 2

Bindra (1960) and Patel (1962) got higher yields to the extent of 60 and 55.9 per cent, respectively, as a result of termite control. In western Rajasthan, Sharma (1967) put the loss upto 15 per cent. Sood et al. (1970) from Madhya Pradesh mentioned 30 per cent loss in unirrigated light soils. Srivastava and Lal (1973) revealed damage ranging from 0.5 to 34 per cent from Uttar Pradesh. During the survey of various districts of Rajasthan it has been assessed that wheat and barley crops may suffer loss upto 35 per cent under unirrigated and tube-well irrigated conditions in lighter soils (Plate II Fig. 1,2 and Plate III Fig. 1). The intensity of infestation varies from place to place and season to season. Recently, heavy crop losses of wheat and barley were reported for district, Pali, Rajasthan (Batra and Singh, 1979).

Damage by termites is often detected only when the mischief is already done in the crop. Hence, the cultivators are compelled to adopt prophylactic measures to protect their crops. In consequence, indiscriminate applications of high dosages of persistent chlorinated hydrocarbons are often made. In this context Brown (1951) has rightly emphasized that "in crop protection the chemical weapon should be used as a stiletto, not as a scythe". Sands (1960), Katz (1979) and Lewis (1980) also cautioned regarding the general application

PLATE II

Fig. 1 Termite free wheat crop

Fig. 2 Termite infested wheat crop

PLATE II

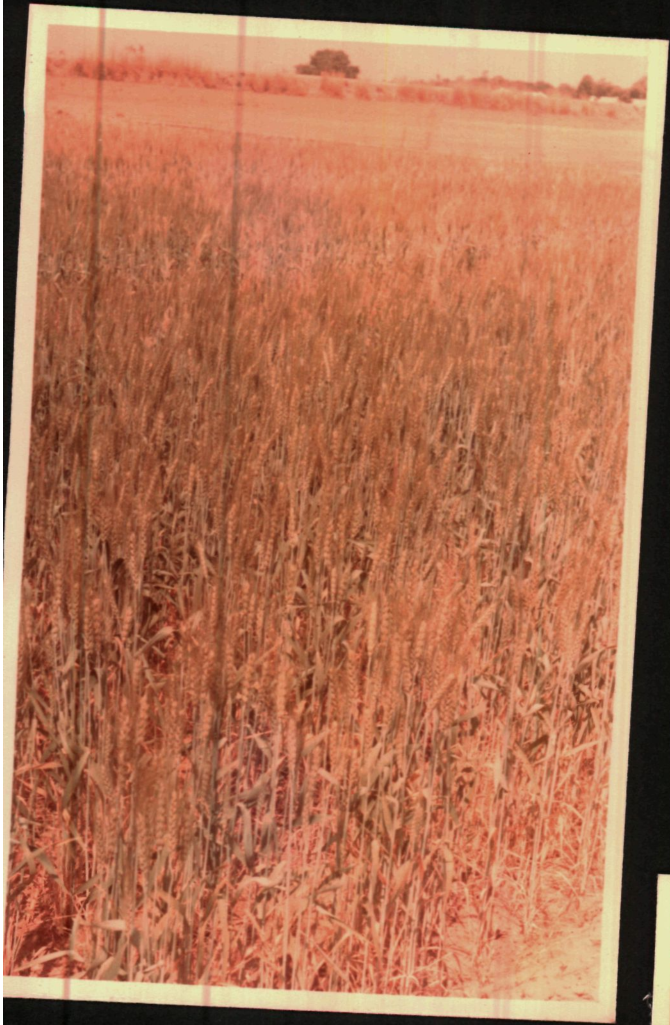


FIG. 1

FIG. 2

PLATE III

Fig. 1 Termite infested barley crop

PLATE III

FIG. 1

of broad-spectrum insecticides. Limiting the use of general application of pesticides in small scale farming in our country need recognition in view of the economical considerations besides the danger of their persistence in the environment affecting the non-target organisms. Hence, local application should be preferred to wide-spread broadcasting in soil.

Pre-sowing soil application of insecticides, seed treatment with insecticides, drenching the soils with insecticide during irrigation in standing crop and extermination of termite colonies by treating the mounds are some of the pertinent approaches employed for termite control.

Seed treatment as one of the cheapest methods of pest control is quite convenient and demands only small quantities of toxicant. Insecticidal seed treatment has been tested against several cereal pests in Britain, Canada, U.S.A. and Australia. On several occasions, these experiments appeared somewhat disappointing. The probable reasons for the failure of some compounds to protect the planted seed or crop were either their ineffectiveness against the pest or injury to the germinating seed due to lack of sufficient knowledge of the insecticide and seed relationship. An initial attempt in Rajasthan to study the effect of insecticidal seed treatment by the author during 1964-65 (Anonymous, 1970) revealed adverse effects of chlordane and heptachlor powders when applied either as dry or with mineral or vegetable oils as sticking agents. Therefore, for choosing an ideal pesticide for seed treatment certain biological requisites as mentioned below are essentially to be looked into:

- pesticides should have a large safety margin between the dosage that destroys the pest and the dosage that harms the germination of seed.

- the seed must be covered uniformly with the chemical.

- the chemical must adhere firmly to the seed to avoid dislodging of powder formulations during handling following the treatment.

- be compatible with other compounds used on the seed.

- should not produce harmful residues in the soil or the plant.

The efficacy of pesticides against termites is largely governed by their application rates. The adherence of powder pesticides is known to be regulated by its specific formulation or by the use of stickers. Whereas pesticides applied through sprays can be easily loaded on the seed at the desired dose. So far, little is known regarding the amount of actual pesticide retained on the seed when applied in powder form. This fact is necessary to know in order to fix the dosages of powdered formulations for seed treatment as the pesticidal application should be harmless to the germination and growth of the plant. The advent of new compounds in powder and emulsifiable formulations necessitates their evaluation for the control of termites through seed treatment keeping in view their practical application with regard to germination and growth. Practically no information on these aspects was available in the literature for barley crop, and only fragmented and outline knowledge available for wheat crop can not be directly utilised for the conditions prevailing in Rajasthan. It was, therefore, considered pertinent to undertake seed treatment studies in detail with a view to elucidate the efficacy to certain pesticidal applications on the control of termites in wheat and barley crops after meticulously scanning their effects on germination and plant growth in order to evolve feasible control measures.

Post-sowing control of termites with the application of pesticides through irrigation water has widely been recommended. The conventional recommended dosages are very high, however, some recent studies indicated effectiveness of lower dosages (Verma *et al.*, 1974; Sandhu and Sohi, 1977). It was, therefore, considered indispensable to work out the minimum effective dosages of some promising compounds to reduce the cost of control operation and to maintain their bioconcentration in the environment at a low ebb.

The efficiency of a chemical for mound poisoning depends on a number of factors especially the insect species involved and thus needs an assessment prior to its adoption in a new area. Further, this method has usually been appraised only on the basis of its role in destroying the treated termitaria and not attempted to discover its impact in reducing the level of termite infestation in crops raised subsequently. It was, therefore, envisaged to test the feasibility of this method in the semi-arid region of Rajasthan.

Against the background of all these reasons the present investigations were contemplated along the following lines.

1. Relative adherence of pesticidal powders to wheat and barley seeds with and without stickers at different dosages.
2. Green-house tests of wheat and barley seed treated with pesticidal powders and emulsifiable concentrates

at various dosages to study their effects on germination, emergence period and plant growth parameters.

3. Microplot field tests of wheat and barley seed treated with pesticidal powders and emulsifiable concentrates at various dosages to study their effects on germination and tillering.

4. Field trials to compare the efficacy of various pesticides through seed treatment against termites in wheat and barley crops.

5. Evaluation of different insecticides and dosages applied through irrigation water in growing wheat crop for the control of termite infestation.

6. Determination of the relative efficacy of certain chemicals for the destruction of mound inhabiting colonies of termies.

CHAPTER II

R I V I E W   O F   L I T E R A T U R E

Adherence of Pesticides

Pesticides differ in their ability to adhere to a treated surface. It is usually considered that the smaller the particles of a pesticide deposit, the greater its tenacity. However, Heuberger (1942) did not find difference in adherence of 0.5 and 0.2 micron particles that were otherwise identical. Decker *et al.* (1950) observed that toxaphene and chlordane leaving waxy or sticky deposits adhered more effectively than those that left crystalline deposits such as DDT.

Srivastava (1955) found that significant increase occurred in the coating as the concentrations were increased. The rates of increase of various pesticides were not uniform and 'Seed Guard' gave the highest coating to different varieties of cereals than lindane, heptachlor or aldrin as dry seed dressing.

Starks and Lilly (1955 a) in their studies of insecticidal seed treatment to soybean found that the combination of lindane with the fungicides somewhat increased seed coat adherence. These authors in a further publication reported that methyl cellulose as sticker was superior to dry application of lindane, since it gave an even coverage leading to reduced seedling injury at higher dosages of lindane (Starks and Lilly, 1955 b).

Generally, methyl cellulose is dissolved in water to make 2.5 to 3 per cent solution to act as sticker involving liquid applications (Reynolds, 1958). Metcalf and Flint (1962) mentioned that the use of dusts impregnated with oily materials, was sometimes of advantage in increasing deposits. Moreover, several materials such as casein, gelatin, soybean flour, blood albumen, various clays, bentonites, petroleum and vegetable oils were mentioned as stickers to increase adherence.

Hoskins (1962) while reviewing some important properties of pesticide deposits on various surfaces has also summarised that dusts are often highly charged and their adhesion to a surface is partially controlled by electrostatic forces, whereas in case of spray particles, it occurs to a much smaller degree.

Ebeling (1963) in a critical review analysed the various basic processes involved in the deposition of pesticides and noted that various factors like size, shape of particle, the size spectrum, the chemical and physical properties of the diluent and the adjuvants to a great extent determine the variations in the actual quantum of the dust deposited on the treated surface.

Griffiths et al. (1970 a) tested wheat seed dressings with four organophosphorous compounds in standard siliceous earth formulations to compare with special formulations of the same compounds in polyvinyl acetate, polypropylene or wax. The special formulations allowed more insecticide to be placed on the seed. In another study, Griffiths et al. (1970 b) dressed the winter wheat seeds with powders containing an organo-mercury fungicide mixed with gamma BHC, chlorfenvinphos or ethion. The results analysed by gas liquid chromatography revealed that the ethion dressing adhered to the seed considerably better than chlorfenvinphos dressing or than gamma BHC alone or combined with the fungicide.

Lord et al. (1971 a) analysed the commercially dressed cereals, mostly wheat to work out the retention and distribution of pesticides. They found that the average loadings of seeds treated with dry powder formulation were nearly always small, but the distribution of insecticide between seeds was fairly uniform. Insecticides applied as dry powders did not adhere strongly to the seeds but they remained in association with the seeds contained and carried in bags. On the other hand, the average loading of seeds treated with liquid formulation was closer to the target, but the distribution was irregular, most of the seeds carried little insecticide and few seeds carried amounts large enough to be phytotoxic.

Investigations on the effect of insecticide-fungicide combination on adherence to the wheat seed were done by Griffiths *et al.* (1972). They observed that the combination of powder fungicide and liquid insecticide, greater amounts of pesticide on the seed were obtained if the insecticide was out on first.

Baicu and Diaconu (1972) determined the adherence of pesticide products to seed given as dry treatment. They observed that out of the insecticides and insecticide-fungicide mixtures used in the experiments, the best adhesiveness was that of PEI-120, PEB and TBZ on wheat, benlate on sugarbeet and quinoate V-4-x on flax seed. The adhesiveness on the seeds depended, primarily on their size, as smaller seeds retained larger amounts of pesticides. The successive handling of the dressed seeds resulted in important losses of pesticides.

Large quantities of powder may be applied with the use of adhesives as evidenced by Jeffs (1973) and Jeffs and Walker (1973), since in the laboratory systemic fungicide formulations were applied successfully at the rate of 16 g of 50 per cent powder per kg of barley seed. This dosage would give a loading of 640 ug of powder per single seed.

The adhesion of the powder was greatly increased when wheat seed and a powder formulation were vigorously mixed for long enough (Jeffs, 1976). This was because the particles were distorted to give an increased area of surface contact. The particle size of the powder also affected its adhesion, perhaps a certain size of particles were easily entrained by the irregular parts of the surface. Jeffs and Tuppen (1978) in an article dealing with the application of pesticides to seeds have mentioned that adhesion of particles to a surface is a complicated process brought about by many factors, from molecular forces to physical trapping of small particles. In the absence of adhesives on the seed or in the formulation, adhesion is due almost entirely to physical trapping, by beard and wrinkles on the surface of wheat seed.

Effect on germination and growth

Phytotoxicity to the crop is a major consideration while applying the pesticides in the soil or in the development of seed treatment. Maximal phytotoxicity is manifested by non-germination of a seed or other symptoms of variable categories like, delayed germination, retarded growth, atypical growth or plant injury. Most agricultural crops appear to show a fairly high degree of tolerance to recommended dosages of soil insecticides

(Fleming, 1948; Foster, 1951; Cox and Lilly, 1952; Fleming and Maines, 1953). Any treatment which places the chemical involved in as intimate contact with the seed and tender germinating plant parts, as seed treatment may cause plant injury (Reynolds, 1958). When prophylactic treatments are applied, phytotoxicity can not be tolerated.

Hays (1920), in an attempt to control <u>Solenopsis molesta</u> Say, tried kerosene, turpentine, nicotine sulphate, oil of lemon, camphor, crude and refined carbolic acid and two brands of commercial chicken dip, composed largely of crude carbolic acid and creosote as seed treatment. He found that many of them were detrimental to the germination of seed. Many early attempts have mentioned adverse effects with the use of chlorinated hydrocarbons, mainly the BHC, DDT and lindane in several garden and field crops, particularly the vegetables (Morrison <u>et al</u>.,1945 a,b; McLeod, 1946a,b; Arnason <u>et al</u>., 1947; Brooks and Anderson, 1947; James and Anderson, 1947; Fleming, 1948; Morrison <u>et al</u>.,1948; Stoker, 1948; Kostoff, 1948, 1949; Lange <u>et al</u>., 1949; Foster, 1951; Fleming and Maines, 1953; Elmore, 1953; Gould, 1955; Starks and Lilly, 1955a,b). Of the grain crops sorghums are among the most sensitive (Cox and Lilly, 1952).

King *et al*. (1948) reported that for cereal crops, especially wheat, treating the seed with special concentrated preparations of BHC showed great promise against wireworms. He, however, did not recommend it for general use until more is known regarding possible injury to seed or seedlings. Fleming (1948) reported that barley and wheat grew normally in the soil treated with 25 lb of technical DDT per acre.

Kostoff (1948,1949) treated the seeds and seedlings of certain plants with hexachlorocyclohexane and found cytogenetic changes and atypical growth in the seedlings. In gramineous plants the insecticide induced atypical growth suppressing the development of the roots, stem and coleoptile and causing striking thickening of these organs especially the growing points.

Cullinan (1949) found depressed growth of some seedling plants when DDT, BHC, chlordane and toxaphene dusts were applied to soil at 25 lb, per acre. Root systems were injured more by BHC and chlordane than by DDT. In vegetables, chlordane was toxic to seedling plant than BHC. It severely affected germination at 25 lb per acre. With BHC emergence was affected but not the germination. Injury to plants was noted on soils low in organic matter.

Hocking (1949) treated seed wheat with various preparations and constituents of BHC to observe the effects on germination and development. He evidenced that plant deformation was not due to gamma isomer but caused by a mixture of trichlorobenzene and relatively small doses caused inhibition of germination. In further investigations (Hocking, 1950), it was noted that all the plants grown from wheat seed treated with crude BHC showed browning and swelling of the root tip, shortened roots, absence of root hairs, and a shortened, thickened and flattened coleoptile but the symptoms were less pronounced in case of pure gamma BHC. In a further series of tests it was confirmed that trichlorobenzenes prevented germination at the higher doses and retarded it at the lowest dose. Even the seeds of some varieties of wheat, oats and barley exposed to different isomers of trichlorobenzenes caused total or partial failure of germination, or greatly retarded growth.

Primost (1950) observed that when barley, rye, wheat and oats were dusted with 0.1 and 0.2 per cent 'Gesarol' containing 10 per cent DDT and planted in sand 10 days later, germination was not affected by the lower rate. But with the higher rate, percentage of viable seed was slightly reduced, the time required for germination increased and subsequent root development was inhibited. In case of barley the adverse effects were negligible.

Faber (1951) discovered that germination of seed wheat was somewhat stimulated by soaking in BHC emulsion.

Jameson and Callan (1951) treated wheat, barley and oats seed with 'Mergamma' containing organomercurial and gamma benzene hexachloride at various rates. They found that levels of gamma benzene hexachloride, safe in practical tests in the field and in the box tests in soil, were markedly phytotoxic in conventional germination tests in sand or on damp filter paper. A dose of 250-500 ppm caused checking and thickening of the shoot and characteristic clubbing of primary roots and the doses above 500 ppm led to suppression of normal growth. Phytotoxic effect of seed dressing under different soil and climate using 20-70 per cent gamma BHC on winter oats and wheat were observed by Jameson et al. (1951). Concentration of 20-30 per cent gamma BHC slightly retarded the appearance of the seedlings above ground but the effect disappeared after a few days, at 70 per cent, the growth was seriously retarded. In laboratory tests of the effect of overdressing, germination of seed treated with 70 per cent gamma BHC at 2 oz or 35 per cent at 4 oz per bushel was delayed.

Cox and Lilly (1952) investigated the effects of aldrin and dieldrin on germination and early growth of field crop seed in green-house. Insecticide levels ranging from 2 to 128 pounds (technical) per acre were taken for barley, buckwheat and winter wheat crops.

Barley was found to be more tolerant than wheat to aldrin. Dieldrin did not cause any severe adverse effect on germination or average green plant weight in both these crops. However, in general on wheat, aldrin at higher doses caused decreased per cent emergence, drop in average green weight and some deformity of plant growth and chlorosis.

Frost et al. (1954) determined the effects of dieldrin and lindane, and of certain fungicides upon the emergence of seedlings of green peas, spinach, onion, cotton and nine varieties of cucurbits. They observed that when insecticides were used without a fungicide, the seed was more predisposed to injury by decay organisms, and plant emergence was often less than in untreated plots. Lindane and thiram combination gave better seed protection than other treatments.

Srivastava (1955) evaluated six chemicals (insecticides and insecticide-fungicide formulations) as seed treatment on some cereals. In general 'Seed guard' produced a beneficial effect on the germination of most of the cereals tested. Pawnee wheat sustained a germination injury when treated with Panogen, PL-1 and also gave a highly significant root-top ratio than all the other treatments.

Starks and Lilly (1955 a) in their studies of insecticidal seed treatment to soybean varieties, observed that high dosages of BHC did not affect large reductions in total emergence or mean green weight under green-house conditions. Starks and Lilly (1955 b) while investigating the effects of seed treatment on dent corn observed deficiencies in green weight caused by high dosages of lindane.

McEwen _et al_. (1957) compared the relative effectiveness of various insecticide-fungicide seed treatments on lima beans. Freshly treated seeds with both insecticide and fungicides or with fungicides only resulted in about 90 per cent stand, untreated seed and that treated with aldrin or gamma BHC alone in about 70 per cent stand, and that treated with diazinon alone in about 50 per cent.

The findings of the termite research scheme at Anand (Agarwala, 1956-57) concluded that the seed treatment of wheat with BHC as with other insecticides did not give any better germination or better stand or increased yield.

Chatterji _et al_. (1958) conducted trials by using DDT, BHC, toxaphene and dieldrin dusts in the soil before sowing upto 20 lb per acre against termites in wheat crop. They did not observe significant difference in tillering by various insecticides as compared to control.

In the trials conducted by Bindra (1960), dusts and wettable powders of several insecticides were mixed with wheat seed for the control of termites. BHC, lindane and chlordane affected germination and inhibited growth. Aldrin and dieldrin gave complete protection against termites and appeared to stimulate growth and tillering and hasten maturity.

Patel (1962) reported that a higher dosage of BHC (4 lb of 50 per cent BHC per 112 lb seed) in seed dressing was harmful to germination of wheat crop. Similarly, Reddy (1962) also indicated about the reports of adverse effect of BHC on the root formation of certain cereal crops. While, Ghosh (1964) with the pre-sowing soil treatment of aldrin, chlordane and BHC at the rate of 3.4, 2.27 and 3.4 kg a.i. per hectare did not observe adverse effect on germination and growth of wheat crop. Instead, phytostimulation due to aldrin treatment was noticed.

Bowling (1964) conducted studies on the germination and emergence of rice seed treated with three formulations of aldrin at two different rates. Fifty and seventy five per cent wettable powder at the rate of 4 and 8 oz a.i. per 100 lb of seed caused little or no detrimental effect on germination and emergence of seedlings. A liquid formulation (4 lb a.i. aldrin per gal) at both the 4 oz and 8 oz a.i. rates caused greater reduction in germination, and emergence. In further investigations, Bowling (1965) treated seed rice with various insecticides and fungicides alone and in combination with each other to study the effect on germination and emergence, and seedling number and larval population of rice water weevil *Lissophoptrus oryzophilus* (Kuschel) in small plots. Aldrin liquid or endosulfan liquid showed a greater reduction in germination than the other treatments with wettable formulations. Thiram exhibited phytotoxic effect in the germination test. All the treatments except endosulfan liquid produced growth (seedling height) equal to or significantly better than the untreated check. In the emergence and small plot tests the results were reversed, and the treatments with thiram produced the best results. None of the data indicated incompatibility between insecticides and fungicides.

Sahni and Butani (1966) got very good germination and yield when wheat seed was treated with aldrin emulsion. They also observed the superiority of seed dressing with BHC dust and wettable powder (doses not mentioned) over the control as evidenced by better germination and higher yield.

Sachan *et al.* (1967) applied four insecticides viz., aldrin, BHC, chlordane and dieldrin to the soil at three different dosages to study their effect on emergence tillering, leaf number and height of wheat plants. Aldrin delayed emergence as the dosages increased except at 3 lb a.i. per acre. BHC treatment showed no significant retardation in seedling emergence. Dieldrin showed significant increase in final emergence. Chlordane was observed to be highly toxic to germinating seedlings. There was no significant effect on height, tillering and leaf number except in chlordane treated plants.

Durand (1967) evaluated eight compounds as seed coating for the control of Mayetiola spp. on wheat. Gamma BHC at higher rates of application afforded better control, but adversely effected germination.

Seed dressings of organophosphorous and carbamate insecticides at 0.1 and 0.5 per cent toxicant by weight of seed were compared with heptachlor and ethion for the control of wheat bulb fly by Griffiths et al. (1969). During these trials the authors observed that chlorpyriphos and bromophos-ethyl at both rates and B 80833 at the higher one damaged young seedlings. There was only slight damage with phoxim at the higher rate and none with primiphos-ethyl.

Mishra and Chand (1970) tested twelve fungicides for seed treatment against Sclerotium rolfsii of wheat.

They found that Tritisan, Brassical and thiram promoted best seedling vigour and root development. Gupta and Mishra (1970) reported that seeds of mung sown in clay loam soil treated with carbaryl at 5 to 50 ppm adversely affected the germination particularly at higher dosages. Different results were obtained by Griffiths et al. (1970 b) in different soils with gamma HCH treatment to wheat and dosesupto about 50 ug per seed did not affect germination in peaty loam soil. However, all gamma HCH treatments in sandy loam soil adversely affected germination. Although insect control improved with the increased loading of insecticide but untreated seed gave better scores for plant vigour than any insecticide treatment even after insect attack.

Allen (1971) evaluated six promising materials for the control of a cereal borer, Dasiantha caudata Pasc. and their effect on germination and plant growth of wheat. Those applied as seed dressings with the weight of toxicant per bushel seed, were phosalone or methomyl (both at 2 and 4 oz, methomyl at the higher rate alone or with a fungicide), endosulfan (4 oz) and diazinon (3 oz). Methidathion and chlorfenvinphos were applied with super-phosphate at 8 and 6 oz toxicant per bushel, respectively. All the insecticides except endosulfan reduced the number of germinating seedlings, methomyl to a greater extent at the higher rate especially when combined with a fungicide. Where plant numbers were reduced, the number of tillers produced after 172 days either exceeded or did not differ significantly from the number produced by untreated plants. Endosulfan, phosalone and methomyl at the lower rate were sufficiently promising to warrant further tests.

Baicu *et al*. (1971) in their studies on the seed treatment of cereals with fungicides and mixed products in Romania found that only pyracarbolide caused phytotoxic effects.

Wheat seeds of varieties C-306 and Kalyan-227 with BHC wettable powder at the rate of 0.05-0.25 kg a.i. as dry and wet treatment, and with aldrin emulsion concentrate at the rate of 0.1-0.75 kg a.i. per 40 kg seed were tested by Verma *et al*. (1971). They found that except BHC dry at the rate of 0.05 a.i. all the treatments reduced the viability of seed. The reduction in germination varied from 1.6 to 84 per cent in various treatments. There was no difference in the performance of both the varieties to any treatment. BHC wet treatment was more destructive than BHC dry and aldrin treatments.

Dalvi *et al*. (1972) in their results on the influence of pesticides on mungbeans and wheat seeds indicated that various concentrations of menazon, disulfoton and GS-14254 inhibited germination and were also considerably effective against seedling growth. It was also noted that the seedlings surviving the pesticide treatment were distorted and weak. The degree of inhibition of germination of seeds and seedling development depended on the concentration of the chemicals. The effects were more pronounced in wheat than in mungbeans.

Griffiths _et al_. (1972) studied the biological effects of combining carboxin, organomercury fungicides and insecticides (aldrin, carbophenothion or chlorfenvinphos as liquid formulation or a gamma BHC powder formulation) as seed dressings for wheat. They found that gamma BHC with organomercury fungicide decreased the number of plants that germinated and gamma BHC with carboxin and organomercury was even more deleterious.

Ozkan and Finci (1974) while using certain pesticides observed that preparations containing gamma BHC applied as seed dressings to wheat either dry or with 1.5 per cent water, many of the seeds that did not germinate gave rise to malformed plants. Additional tests with eight varieties of wheat showed that gamma BHC even at an application rate of 0.02 per cent affected germination and seedling shape regardless of the wheat variety concerned. The somatic chromosomes in the root-tips mitoses were analysed by Zeller and Hauser (1974) after treatment of barley, rye, summer wheat and oats with seed dressings containing gamma BHC. Most of the chromosome sets in the root tip cells were found to have been polyploidised. Tests with pure gamma BHC showed that this insecticide was responsible for the induction of polyploidy.

Verma (1974) studied the effect of seed treatment with BHC and aldrin dusts on germination using wheat seed of variety C-306. He documented that wetted seed dressing with aldrin dust even at the highest dose of 1.5 kg a.i. (10 kg of 5 per cent) per 40 kg seed had no adverse effect on the germination of wheat seeds. Whereas, in the case of BHC the percentage germination obtained with 0.05 and 0.1 kg a.i. doses was comparable with the control and any further increase in the dose adversely affected the germination. In fact with doses from 0.3 kg to 1.0 kg a.i. of BHC, the germination was almost negligible. Verma <u>et al</u>. (1974) in a trial on the effect of BHC and aldrin on termite damage in irrigated wheat crop, where insecticides were applied by different methods, found that wheat seeds treated with BHC at the rate of 1.25-2.5 kg a.i. per hectare did not germinate. Though the observations were not recorded, it was however, noted that seed dressing with aldrin at the rate of 1.875 kg a.i. per hectare brought about a negligible reduction in germination. Verma <u>et al</u>. (1979 a) treated the wheat seed obtained after threshing with BHC 10 per cent or malathion 5 per cent dust @ 250 and 125 ppm a.i. respectively, and then stored. Subsequently, germination observations recorded after 21 days of sowing in 1973-74 and 1974-75 revealed the germination of treated seeds as good as that of untreated seeds. In trials on barley Verma et al. (1979 b) found that none of the aldrin and BHC soil or seed treatments improved germination over control during three years of experimentation. However, during 1975-76 aldrin 30 e.c. at the rate of 15 and 20 ml per kg seed adversely affected the germination.

Chemical control of termites

The chemical control of termites for the protection of wheat and barley crops involves a four pronged approach viz., soil treatment, seed treatment, post-sowing treatment with irrigation and mound treatment, of which the latter three are reviewed here in view of their direct bearing with the present line of investigations.

Seed treatment:

David and Gardner (1955) mentioned that seed treatment was thought of as early as A.D. 50 by Junius Collumella. Pliny in A.D. 60 described the use of wine and crushed Cypress leaves for this purpose as quoted by Horsfall (1945) and Martin (1959). No further attempts to treat seed were recorded until 1920 when Becon compared the treatment of cereal seeds with dungs, ashes and soot or alcohol probably with the objective of controlling diseases (Ordish, 1977). In 1937, Remnant described a seed treatment for bunt, which may be the earliest record of the use of brine for this purpose (Horsfall, 1945). Tillet in 1750 planted experimental plots with untreated seed or treated with salt and lime, or nitre and lime which must be regarded as the first scientific seed treatment experiment (Ordish, 1977).

A number of references regarding seed treatment with arsenic or corrosive sublimate (mercuric chloride), copper sulphate and formalin during the early 20th century have been mentioned by Horsfall (1945), Martin (1959) and Ordish (1977). The development of organochlorines transformed the situation and their use as seed treatment was pioneered in Great Britain, Canada and the U.S.A. The first use of organochlorine insecticides was introduced for seed treatment by Jameson et al. (1947). With increased intensification of cereal growing, the problems caused by pests and pathogens were exacerbated so that a greater proportion of seed had to be treated with insecticides as well as fungicides.

A number of papers are available on insect pests of cereal crops where insecticidal seed treatments have been tested by various workers against southern corn rootworm

(Eden and Arant, 1953), false wireworm (Daniels, 1955), seed attacking beetle (Starks and Lilly, 1955 b), wheat cury mite (Kantack, 1955; Kantack and Knutson, 1958), Hessian fly (Brown, 1960; Guyer *et al*., 1958; Wilson *et al*., 1960), grasshoppers and wheat stem fly (Skoog and Wallace, 1964), cereal leaf beetle larvae (Ruppel, 1969) and curculionid beetles (Allen, 1971).

Narayanan and Rattan Lal (1952) reviewed the chemicals tried by the Department of Agriculture, Punjab during 1925-29 as seed treatment against termites. It appears to be the first attempt of seed treatment tested for the control of termite infesting wheat crop in India. The treatment with mercuric chloride 0.25 per cent or copper sulphate 0.55 per cent was found to be effective as a deterrant against termites and their viability was not affected. The trials conducted by these authors at Delhi for the control of termites (generally *Microtermes obesi*) attacking wheat crop during 1945-46 did not find significant difference among various treatments due to low infestation. However, during the second year the treatment of wheat seed with pp-DDT 5 per cent emulsion and gamma BHC 0.5 per cent dust were significantly effective in checking the termite attack.

Bindra (1960) conducted trials in Madhya Pradesh by mixing insecticides with the seed for the control of wheat termites (mentioned several species including *Microtermes* spp. and *Odontotermes obesus*). Aldrin and dieldrin both gave complete protection against termites. He recommended mixing of aldrin 5 per cent dust with seed just before sowing at the rate of 20-40 lb per acre on the basis of good protection, giving higher yield and being cheaper than dieldrin. In Gujrat, Patel (1962) found seed dressing at the rate of 2 lb of BHC 50 per cent per 112 lb of seed highly effective in reducing termite attack by 86 per cent and increasing grain yield by 55. 9 per cent over control in wheat crop.

Rose (1962) reported satisfactory results with dieldrin as a seed dressing at a rate of 1 lb of 50 per cent wettable powder to 240 lb of maize seed. Bigger (1965) in Tanganyika for the control of termites in maize and soya crops found seed dressing of dieldrin 75 per cent at the rate of 0.1 oz per lb seed as excellent and cheaper than soil application of aldrin. The yields raised by 330 to 500 lb in maize and of soya by 110 to 180 lb per acre.

In Haryana, Sahni and Butani (1966) conducted a trial against termites (*Odontotermes obesus* and *Microtermes obesi*) responsible for damage to wheat crop. They obtained good germination and higher yield over the control when wheat seed was treated with aldrin emulsion and BHC suspension. However, the exact dosages used were not indicated by them but they recommended one litre a.i. of aldrin per quintal of seed in required quantity of water.

From Rumania, Baicu et al. (1971) reported seed dressings and sprays of fungicides and insecticide-fungicide combination to wheat and barley for the control of Zabrus tenebriodes (Geoze) and fungal diseases. Mixed treatments containing gamma BHC and thiram and either hexachlorobenzene or cupric trichlorophenolate afforded good protection against this beetle.

Verma et al. (1974) evaluated the effectiveness of aldrin and BHC with dosages ranging from 0.625 to 1.875 and 1.25 to 2.5 kg a.i. per hectare, respectively, by various methods for the control of Microtermes obesi in wheat. They obtained lesser tiller damage at growth and ear-forming stages with higher yield than control by aldrin seed dressings but treatment by this method was found to be inferior to pre-sowing soil treatment and application with irrigation water in respect of yield. Further field experiments for the control of Microtermes obesi in wheat were conducted under irrigated and dry farming conditions by Verma et al. (1975). BHC dust or wettable powder and aldrin as dust or emulsifiable concentrates were applied to dry or moistened seeds or soil before sowing. An emulsifiable concentrate of aldrin applied at 125 g toxicant per 100 kg seed proved most effective. Seed treatments with dust of BHC at 125 g and aldrin at 62.5 g per 100 kg seed improved the yield although they were less effective in checking termite attack.

In Punjab, Chahal et al. (1976) found seed dressing of wheat with aldrin 30 e.c. at the rate of 240 ml added to one litre of water for 30 kg seed as highly effective and cheaper than BHC treatment.

Sands (1977) has given the dosages of several insecticides used or recommended by various authors for seed dressing against termites of cereal crops which ranged from 200 to 900 g a.i. per quintal of seed.

Experiments on the effects of treating wheat seed with either BHC 10 per cent or 5 per cent malathion at the rate of 250 and 125 ppm a.i., respectively were carried out by Verma et al. (1979 a) during 1973-75. Significantly less termite damage occurred in plots raised from treated seeds than the controls during the second year although no significant difference was found in the first year. The per cent increase in grain yield over controls were 26.7 and 13.4 for BHC and 19.7 and 29.7 for malathion in 1973-74 and 1974-75, respectively. Trials against termites on rainfed and irrigated barley crop were conducted by Verma et al. (1979 b). Aldrin emulsifiable concentrate and dust and BHC dust was used for seed treatment, and in soil application dusts of aldrin and BHC were taken. Aldrin 30 e.c. at the rate of 10 ml (after diluting with water to make 125 ml emulsion) per kg seed proved to be the best as regards termite control, grain yield and economics of treatment. Aldrin 5 per cent dust at the rate of 10 g per kg seed was also effective.

Post-sowing treatment:

Ayyar (1938) suggested mixing of crude oil emulsion or tar water with irrigation water for the control of *Microtermes obesi* on wheat in south India.

Srivastava et al. (1962) treated the termite infested wheat crop at the rate of 20 and 25 lb per acre both with aldrin 5 per cent, BHC 5 per cent and heptachlor 6 per cent dusts. Aldrin at the rate of 25 lb per acre gave effective protection, reducing plant mortality from 71.0 per cent in control to 2.9 to 3.5 per cent in treated plots. The treatments with BHC 5 per cent and heptachlor 6 per cent dusts were less effective.

Verma et al. (1974) used three different dosages of aldrin emulsifiable concentrate and BHC wettable powder with first irrigation after 25 days of sowing to wheat crop to check the infestation of *Microtermes obesi*. They found that all the three dosages of BHC and the lower two dosages of aldrin did not prove better than control with regard to damage during the growth stage of the crop. However, all the insecticidal treatments proved better than control in reducing crop damage during the ear-formation stage and also in increasing yield. Aldrin at the rate of 1.875 kg a.i. per hectare with irrigation water was found to be one of the best treatments. Presowing soil application and seed dressing treatments were also at par.

Sandhu and Sohi (1977) for the control of two widely distributed species of termites (Microtermes obesi and Odontotermes obesus) infesting wheat crop in Punjab recommended broadcast in standing crop of 50 kg per hectare of sand impregnated with 0.625 to 1.25 litre of aldrin 30 e.c. formulation in 5 litres of water. It was found effective for irrigated and unirrigated crops both. Moreover, all doses of aldrin 30 e.c. formulation from 0.625 to 5.00 litre were also found effective when applied with irrigation water. The control ranged from 83 to 90 per cent. Alternatively, BHC 50 per cent wettable powder used at the rate of 1.25 kg per hectare and other higher dosages proved effective which gave 82 to 90 per cent control.

Mound treatment:

Termite mounds form the foci, wherefrom infestation spreads to the neighbouring fields. Therefore, the destruction of these mound-building termite colonies is necessary to "nip in the bud". In Rajasthan, the most common mound-building species of termite which infests the agricultural crops is Odontotermes obesus (Rambur).

Several methods and chemicals have been suggested for the control of mound-inhabiting termites. Andrews (1913) reported the testing of fumes liberated from a special compound which were pumped into the mound by a 'Universal' machine for about half an hour. A deposit of sulphur for some distance showed insufficient combustion due to lack of air and thus partial success was achieved in killing the inhabitants.

It has long been believed that if the termite queen is killed, the entire colony is eradicated (Fletcher, 1914; Ayyar, 1938). But such measures often resulted in only a temporary reduction of termite population because the supplementary reproductives had the capacity to re-establish the colony after sometime (Harris, 1961). Therefore, the alternative method of use of chemicals, being more effective was advocated.

Glover (1937) suggested the blowing in of hot poisonous gases over live charcoal in a brazier. Beeson (1941) recommended the removal of above ground parts of the termitaria and inserting of 0.25 to 0.50 oz arsenic powder mixed with dust through the exposed cavities of each termitarium. He also suggested the blowing in of pure white arsenic powder into a hole made with a crowbar or soil auger from one side towards the centre of the mound. Another recommendation given by him was the use of fumigants like creosote and kerosene or petrol (1:3) mixture, carbon bisulphide or carbon disulphide emulsions or dichlorobenzene liquid or crystal.

Mukerji and Mitra (1948) reported that mound inhabited colonies of Odontotermes redemanni (Wasmann) in west Bengal were successfully exterminated by various organic and inorganic chemicals including kerosene oil (at 1 gal per 14 cubic feet of mound volume), DDT (10 per cent dust at one pound per cubic feet) and BHC, DDT and creosote in various proportions in kerosene oil. The Forest Research Institute, Dehradun (Anonymous, 1949) advocated the use of DDT and BHC for the destruction of termite nests. Pruthi and Singh (1950) recommended the fumigation of mounds by carbon bisulphide and ethylene dichloride etc. Geigy Insecticides (1951) suggested pouring of DDT one per cent suspension to the soaking point over the fungal gardens exposed by breaking open the termitarium.

Roonwal (1951, 1952) recommended pouring in either one per cent DDT or 0.2 per cent BHC emulsion into the holes of the termitarium, by means of a funnel at the rate of two gallons per ten cubic feet of mound volume. The volume of the mound was calculated by the formula; $V = \pi r^2 h$, where V is the volume, r is the radius and h the height of the mound.

In Malaya, colonies of Macrotermes gilvus were effectively killed by treatment with 0.04 per cent aldrin emulsion or 0.036 per cent dieldrin emulsion, the former taking a week and the latter 10 days to achieve complete kills (Anonymous, 1954).

Singh and Sharma (1957) proposed a formula for the calculation of mound volume to determine the quantity of liquid required for drenching. They compared various dosages of DDT, BHC and aldrin for the destruction of nests of Odontotermes gurdaspurensis Holmgren and Holmgren. Consistently effective results with aldrin emulsion were obtained for the destruction of termite colonies and even 0.0041 per cent concentration was found enough for the purpose. BHC 0.1 per cent suspension, though effective was not dependable and DDT was partially successful.

For calculating the dosages of liquid insecticide required for effective control of subcylindrical mounds of Odontotermes obesus, Roonwal (1958), proposed a height-dosage relationship table. The quantities of liquid worked out ranged from one gallon to twenty seven gallons for the heights ranging from three to seven feet, respectively.

Bindra (1960) obtained complete control of certain mound-building termites (*Odontotermes* spp. including *O. obesus*) by applying 2 oz of any of the following insecticides per nest; DDT, BHC as 50 per cent wettable powders and emulsifiable concentrates of chlordane 75 per cent, toxaphene 25 per cent, dieldrin 18 per cent, and aldrin 40 per cent at the rate of one oz per nest. The insecticides were dissolved in 10 gallons of water to pour into the termitaria.

Roonwal and Chatterjee (1960) conducted a series of experiments during 1951 and 1956 for the extermination of colonies of mound-building termite *Odontotermes obesus* (Rambur). Aldrin, dieldrin, BHC and DDT were used with different concentrations in 500 to 9000 ml of liquids per 10 cubic feet of mound volume. They concluded that the use of chlorinated hydrocarbons was effective and cheaper in destroying the entire colony in less than a week's time. The cost of insecticide including labour and water per 10 cubic feet of mound at the 1960 price levels was calculated as 18, 20, 21 and 26 paise for 0.005 per cent gamma BHC, 0.04 per cent DDT, 0.025 per cent aldrin and 0.025 per cent dieldrin, respectively. They also stressed that both concentration of the insecticide and the total quantity of the liquid poured into the mound are important in ensuring adequate destruction.

Deoras (1962) tested the dusts, suspensions and emulsions of some insecticides which were applied by breaking open the towers of mounds, inhabited by Odontotermes spp. The use of DDT and BHC five per cent dust at the rate of 2 oz was unsuccessful as the termite workers had either sealed off the treated area or covered it with earthen gallaries to avoid contact with the insecticide. Suspensions of two per cent BHC and DDT, and emulsion of two per cent pyrethrum applied at the rate of one gallon were absolutely successful but two per cent crude oil emulsion was ineffective.

Sands (1962) achieved successful control of Macrotermes natalensis which constructs large mounds in northern Nigeria with 2.5 fluid ounces of aldrin 40 per cent emulsifiable concentrate in six gallons of water applied through auger holes made into the central hive containing the queen cell and associated chambers. A possibility of further reduction in insecticide dosage was also hinted by him.

Roonwal and Guha-Roy (1964) for the Odontotermes obesus type of mounds found that a non-linear equation (a quadratic curve) fits better than a linear one to calculate the volumes of different mound heights e.g. height 1 cm, 2,00,000 ml; 10 cm, 10,75,000 ml; 20 cm, 82,80,000 ml.

Fumigation of mounds with aluminium phosphide (Phostoxin) gave promising results in India as mentioned by Sands (1973), but Bastos *et al.* (1971 reported failure of doses of one to four pellets per mound to control *Cornitermes cumulans*.

Recently, experiments were carried out by Rajagopal and Veeresh (1978) on the mound poisoning of *Odontotermes wallonensis* (Wasmann). The size of the mounds varied from 1 to 5 metre in diameter and 25 to 100 cm in height. Aluminium phosphide at 9 g, phorate 10 per cent granules at 50 g, chlordane 20 per cent emulsifiable concentrate at 50 ml and chlorpyriphos 20 per cent emulsifiable concentrate at 20 ml per mound, completely destroyed the termites including some associated animals inside the mound, if any. Ethylene dibromide at 3 ml and BHC 50 per cent wettable powder per mound were less effective and gave only 50 per cent and 25 per cent control, respectively.

CHAPTER III

MATERIALS AND METHODS

General

The present investigations were executed for three consecutive seasons from 1978-79 to 1980-81. The programme was splitted into three phases viz., laboratory, green-house and field tests. This work was mainly carried out at the Agricultural Research Station, Durgapura, Jaipur, which is a major centre of cereal research in the State. However, some chemical control trials were conducted at cultivators' fields in Jaipur district. The microplot trials dealing with effects of pesticides on the germination and tillering of cereals were taken in a field free from soil pests. Trials on the chemical control were invariably taken on the fields under tube-well irrigation and with a previous history of severe termite infestation. The termite species involved in these studies were Odontotermes obesus (Rambur) and Microtermes obesi Holmgren. In the experiments on extermination of mound inhabited colonies, however, only Odontotermes obesus was implicated.

Kalyan sona wheat and RD 103 barley varieties chosen for experimentation were procured from the wheat specialist and barley breeder of Agricultural Research Station, Durgapura, Jaipur (Mohan Lal Sukhadia

University, Udaipur, Rajasthan). A single properly sifted and cleaned seed lot was used for all the experiments of a crop in each season.

The chemicals included in the present investigations were insecticides with contact and stomach action which belonged to chlorinated hydrocarbon, carbamate and organophosphate groups. Whereas, the fungicides, TMTD and carboxin had contact and systemic action and pertained to dithiocarbamate sulphur and oxathiin groups, respectively. Fresh commercial formulations of these pesticides were obtained during the studies from the following sources.

1. Bayer (India) Ltd. New Delhi
2. Bharat Pulverising Mills, Bombay
3. Hindustan Insecticides Ltd. New Delhi
4. Hoechst Pharmaceuticals Ltd. Ahmedabad
5. National Organic Chemical Industries Ltd. New Delhi
6. Mysore Insecticide Company Pvt. Ltd. Madras
7. Pesticides India, Udaipur.
8. Union Carbide India Ltd. Bhopal

The data collected from the laboratory, green-house and field tests were subjected to statistical analysis. The analysis of variance was done after angular transformation of the percentages (germination and damage). Transformed figures are given in parentheses against their corresponding values in the tables. The rest of the data were processed for the analysis of variance without conversion.

The experimental procedures adopted and the materials employed at the various stages of this work have systematically been enumerated in the following lines.

Seed Treatment

Application of dry pesticidal powders:

The seed was re-examined to remove damaged and unwanted matter for the selection of only healthy grains. The moisture percentage of wheat and barley seeds used for dry adherence tests was determined by air oven method described by Chalam et al. (1967) and was found to be 9.4 and 9.65 per cent, respectively. For laboratory, green-house and microplot tests, 50 g seed samples were prepared. Similarly, samples of pesticidal powders according to the desired rate of application were also made. Screwed cap hard plastic containers of 100 g capacity were ear-marked for each treatment and dosage. Mixing of pesticidal powder with the seed for thorough coating was carried out in two instalments, each followed by hand shaking for a total period of three minutes. The treated seed was then turned into a 40 mesh sieve, shaked ten times in an oscillating fashion to remove the excess quantity of pesticidal powder. It was done in order to simulate the usual fall off of pesticidal powders which would occur in normal transit or transfer before sowing. Subsequently, the coated seed was weighed to determine the quantity retained on the seed.

Thirteen dry pesticidal powders (Table 3) with three replicates were taken in the exploratory tests on the relative adherence to wheat and barley seeds separately at the rate of 2 kg per 100 kg seed. In other tests, dry powders of aldrin, BHC and chlordane were applied at the rate of 1, 2 and 4 kg per 100 kg seed of wheat and barley, each with four replications. Four separate sets of seed treated with thirteen pesticidal powders each of wheat and barley were prepared for green-house and microplot tests before initiation of sowings. The average quantity of dry powders retained on 100 kg seed was also derived from this source and is shown in Table 1 and 2 for wheat and barley, respectively.

For chemical control trials 200 g seed was mixed with the required amount of dry powder in 500 g capacity glass jars having screwed backelite covers. The mixing procedure was similar as described in one of the preceding paragraphs but the duration of this operation was extended to five minutes because of the more quantity of seed.

TABLE 1

Average amount of powder formulations retained on 100 kg wheat seed

Application rates of the formulation, the amount retained and their equivalent a.i.

Sl. No.	Pesticides	2 kg dry		2 kg with sticker		4 kg with sticker	
		Amount retained in kg	g a.i.	Amount retained in kg	g.a.i.	Amount retained in kg	g a.i.
1.	Aldrin 5% dust	0.651	32.56	1.900	95.03	3.704	185.20
2.	BHC 5% dust	0.545	27.28	1.938	96.90	3.884	194.23
3.	BHC 10% dust	0.506	50.60	1.948	194.80	3.858	385.84
4.	BHC 50 w.p.	0.579	289.90	1.794	897.20	3.067	1533.70
5.	BPMC 4% dust	-	-	1.888	75.55	-	-
6.	Carbaryl 50 w.p.	0.520	260.00	1.917	958.50	3.772	1886.20
7.	Chlordane 5% dust	1.365	68.25	1.932	96.63	3.805	190.28
8.	Endosulfan 4% dust	0.539	21.59	1.906	76.24	3.882	155.30
9.	Heptachlor 5% dust	0.702	35.13	1.948	97.40	3.876	193.82
10.	Isophenphos + TMTD 30:10 s.d.	0.681	272.64	1.306	522.40	2.497	998.96
11.	Landrin 50 w.p.	0.279	139.50	1.805	902.50	3.331	1665.70
12.	Larvin 75 w.p.	0.837	628.20	1.747	1310.25	2.973	2229.75
13.	Lindane 0.65% w.p.	0.617	4.01	1.956	12.71	3.938	25.60
14.	Mal + DDT + BHC 3:3:2	0.635	50.83	1.875	150.00	3.872	309.77

TABLE 2

Average amount of powder formulations retained on 100 kg barley seed

Sl. No.	Pesticides	Application rates of the formulation, amount retained and their equivalent a.i.					
		2 kg dry		2 kg with sticker		4 kg with sticker	
		Amount retained kg	g.a.i	Amount retained kg	g a.i.	Amount retained kg	g a.i.
1.	Aldrin 5% dust	0.786	39.30	1.858	92.90	3.641	182.06
2.	BHC 5% dust	0.669	33.45	1.885	94.29	3.818	190.90
3.	BHC 10% dust	0.531	53.10	1.930	193.00	3.815	381.50
4.	BHC 50 w.p.	0.669	334.50	1.775	887.90	2.693	1346.80
5.	BPMC 4% dust	-	-	1.839	73.57	-	-
6.	Carbaryl 50 w.p.	0.605	302.50	1.872	936.20	3.611	1805.50
7.	Chlordane 5% dust	1.476	73.80	1.892	94.64	3.647	182.37
8.	Endosulfan 4% dust	0.603	24.12	1.895	75.80	3.680	147.20
9.	Heptachlor 5% dust	0.812	40.62	1.891	94.58	3.681	184.05
10.	Isophenphos + TMTD 30:10 s.d.	0.812	324.96	1.022	408.80	2.208	883.44
11.	Landrin 50 w.p.	0.316	158.00	1.415	707.90	3.211	1605.80
12.	Larvin 75 w.p.	1.019	764.70	1.228	921.15	2.320	1740.30
13.	Lindane 0.65% dust	0.684	4.44	1.886	12.26	3.858	25.07
14.	Mal+DDT+BHC 3:3:2	0.699	55.96	1.859	148.72	3.750	300.00

Application of pesticidal powders with sticking agents:

Two per cent solutions of sticking agents viz., gum arabic, soluable starch and methyl cellulose were tested for choosing a suitable sticker. In this exploratory test, BHC and chlordane powders at the rate of 2 and 4 kg per 100 kg of wheat seed were applied in four replicates. The sticking solutions were applied at the rate of 5 litres per 100 kg seed. Fifty gramme seed samples were transferred in 100 g capacity container and the measured quantity of the agent was applied drop by drop over the seed surface in two portions, each followed by vigorous agitation by hand to ensure a thorough coating. The weighed quantity of dry pesticidal powder was then sprinkled over the wet seed in three portions, each followed by hand shaking. The total mixing time taken in this case was five minutes for both the steps. The coated seed was then spread over a blotting sheet and dried with an electrical hot air blower. Further, the pesticidal treated and control (sticker treated only) seed lots were placed in an oven at 55°C. The control lots were periodically weighted until they attained approximately their original weight, when all the lots were taken out and weighed. The amount of pesticidal powder adhered to the seed was calculated by subtracting the original weight of the seed from the weight obtained after loading it with the pesticide.

In treatments of seed for green-house and field tests, methyl cellulose solution was used as a sticking agent due to its better sticking quality. Four replicates of seed were treated with thirteen pesticidal powders, each for wheat and barley at the rate of 2 and 4 kg with sticker per 100 kg seed for green-house and microplot tests. The seed was dried and the amount retained on the seed was determined as mentioned in the preceding paragraph. The average quantity retained per 100 kg seed is shown in Table 1 and 2 for wheat and barley, respectively.

For chemical control trials, 200 g seed was mixed with the required amount of sticker and powder in 500 g capacity glass jars. The mixing procedure was the same except that the duration of operation was seven minutes.

Application of emulsifiable concentrates:

The pesticides used in these tests were; aldrin 30 e.c., chlordane 20 e.c., chlorpyriphos 20 e.c., endosulfan 35 e.c., heptachlor 20 e.c., isophenphos 50 e.c., lindane 20 e.c., malathion + DDT + BHC 50 e.c. (25:15:10), phenthoate 50 e.c. and phoxim 50 e.c. Four dosages viz., 80, 120, 160 and 200 g a.i. of these emulsifiable concentrates were prepared by adding water at the rate of five litres of liquid per 100 kg seed. Fifty gramme wheat and barley samples were treated in 100 g capacity containers for green-house and microplot tests. The application of emulsions was done by placing the nozzle of the Potter's tower over the container by releasing a pressure of 25 lb per sq inch. Metered quantities of the liquid were sprayed over the seed in three splits, each followed by vigorous hand shaking of the container to achieve maximum uniformity in coating. The seed was then dried with the help of a hot air blower. Pipettes and treating containers were pre-marked for each pesticide dosage and were reused after thorough cleaning and drying. The spray nozzle was also rinsed and dried after using each pesticide dosage.

For trials on chemical control 200 g seed was taken in 500 g glass jars for the treatment. Where combined treatments with carboxin were involved, the insecticide was first applied followed by fungicidal dressing.

Green-house tests

A series of four pot trials was set up with a schedule of four successive sowing dates during 1978-79 season. Two identical trials on wheat and barley had thirteen pesticidal powder formulations applied at the rate of 2 kg as dry, 2 and 4 kg with sticker per 100 kg seed alongwith their respective controls. Two more trials, one each on wheat and barley were conducted with ten emulsifiable concentrates applied at the rate of 80, 120, 160 and 200 g a.i. per 100 kg seed with their respective checks. Four replications were taken for every trial. The soil used in these tests was brought from a virgin field. It was sifted and a composite sample was drawn to determine its pH which was found to be 8.00. The soil type was loamy sand with the mechanical fractions of 85.10, 4.92 and 8.90 per cent sand, silt and clay, respectively.

Air dried soil was incorporated with water and homogenised to develop approximately twelve per cent moisture which corresponds to the water holding capacity of the soil used here. Clay pots of twenty five centimetre diameter were filled in with equal quantity of the moist soil. The soil top was smoothed with a ten centimetre wooden paddle. Twenty five seeds per treatment were planted in each pot by making one and a half centimetre deep holes and tamped firmly with the soil. The seeds were placed flat on the soil surface by a forcep with the seed-germ facing upwards. In addition, with each set of experiment, unseeded pots filled with the same moist soil were kept to determine the daily moisture loss for irrigating the seeded pots to maintain the moisture level.

Daily seedling emergence counts were noted from fourth day onwards. Final germination percentage was based on the observation recorded on tenth day after planting. Moreover, the mean emergence period being an excellent indicator of the effect of seed treatment was also studied as proposed by Leach and Smith (1945) and also later employed by Lange _et al_. (1949) in their seed treatment studies. For this purpose daily increase in emergence was multiplied by number of days after planting, the sum of these products was divided into the total emergence recorded at the time of last observation.

At the end of the last germination counts, the entire soil alongwith the seedlings was carefully scooped out. Thenceforth, individual seedlings alongwith their seminal roots were delicately removed from the soil. Further, the soil was thoroughly searched to collect the broken pieces of roots. Later on the seedling material was washed for removing the entangled sand particles from the roots by floating the sieve in water trough and finally in running water. The seedlings were then spread over the blotting sheet to remove the excess water. Ten seedlings per pot (except a few exceptions) were randomly selected for measuring shoot height. The height was measured from the base of the germ (sprouting point) to the distal end of the leaf. Subsequently, the whole germinated seedling material of each treated replicate was slipped into the paper bags marked with the treatment, replication and number of seedlings. It was then kept in an oven at 55°C for a week to determine the dry weight of the seedling. Desiccators were used for transferring the dried material from the oven until it was weighed.

Field Trials

Microplot trials:

Four trials with identical treatments as used in green-house tests were sown during the same season after the whole series of pot tests was completed. Four metre row microplots per treatment with three replicates were arranged in a randomized block design. The field was properly levelled by a wooden paddle. Subsequently, about five centimetre deep furrows were made by a hand driven wooden plough. A distance of 50 cm was maintained between the furrows. Hundred seeds in each furrow were placed equidistantly and the soil was firmly tamped down. After the seedling emergence, one metre long observational units were fixed in each replication. Germination and tillering counts were recorded 25 and 100 days after the sowing, respectively.

Chemical control trials (seed treatment):

A series of six presowing chemical control trials through seed treatment was undertaken in two successive seasons. Four trials were conducted during 1979-80, two each on wheat and barley crops with powder and emulsifiable formulations separately. Only those pesticides which had allowed eighty per cent or more germination in microplot tests were promoted for the termite control trials. Aldrin five per cent dust at the rate of 1.25 kg 100 kg seed was an All India Wheat Research Worker's Workshop recommendation for the control of termites in wheat crop (Anonymous, 1977). Therefore, in wheat trial with pesticidal powders, two additional treatments of aldrin dust, one with 1.25 kg and the other with 1.25 kg with sticker were also incorporated. The first trial on wheat was having 25 pesticidal powders alongwith two controls (with and without sticker) and the second with 14 emulsifiable concentrates and a control. A barley trial with pesticidal powders consisted of 35 treatments besides, two controls (with and without sticker) while, the other with emulsifiable concentrates comprised of 29 treatments including a control. Details of treatments of all these trials are given in Table 31 to 34.

Two trials one each on wheat and barley crop were undertaken during 1980-81. Only pesticides which had given most effective results during trials conducted in previous season were choosen for both the trials. In these trials emulsifiable and powder formulations of a new product BPMC were also included. Moreover, with a few emulsifiable treatments, dressing with carboxin was also done. The wheat trial consisted of eleven treatments including the control while barley trial had thirteen treatments in all including the control. Pesticides and the dosages used in these trials are mentioned in Table 35 and 36.

For all the chemical control experiments the seed was treated before according to the exigency of the situation in sowing. Three replications with a randomized block design were taken for all these trials with a plot size of 5 x 4 m. Recommended dosages of fertilizers were applied. Furrows for sowing were made by a wooden plough driven by bullocks followed by replacement of measured quantities of seed in each furrow at the rate of 100 kg per hectare. A distance of 25 cm was maintained between the rows. The net plot measured 4.5 x 3.5 m having fourteen rows of 4.5 m length each. One metre long observational units were randomly ear-marked in each alternate row of the plot.

Observations on the number of germinated plants were recorded three weeks after the sowing and on plant damage, three to five weeks after the sowing. While recording observations the damaged plants were removed each time to avoid their repeat counting in the next observation. Similarly, for recording the number of damaged tillers or ear-heads, the plots were periodically scanned. The data of plant and tiller or ear-head damage were finally pooled to derive the cumulative percentages or numbers. The net grain loss due to ear-head damage was assessed by calculating the difference between the grain weight of equal number of healthy ear-heads with that of damaged ear-heads from the same plot. Single plant thresher was used for threshing these damaged and healthy ear-heads.

Chemical control trials (post-sowing with irrigation):

Two such trials on wheat crop were conducted, one during 1978-79 and the other during 1980-81. In the first year, three replicates were taken in a randomized block design with twenty one treatments including the control (Table 37). During the second year of trial, thirteen treatments including the control (Table 38) were arranged in a randomized design in three replications. Sowing method and fertilizer dosages were the same for both these trials as mentioned for other chemical control trials. Insecticides were applied through first irrigation after about twenty one days of sowing. The measured quantity of insecticide per plot according to the assigned dosage was first diluted in a bucket full of water. The emulsifiable liquid so prepared was gradually released at the water inlet into the plot when the irrigation water had reached about three-fourth area and continued till the irrigation water occupied the whole plot area.

Observations on plant and ear-head damage in number were recorded by surveillance of the whole plot. The damaged plants recorded just before the treatment were pulled out and the next observation was taken two weeks after the treatment, while the ear-head damage was observed twice and represent the composite number. All these observations as well as yield data were converted on hectare basis.

Chemical control trials (mound-building termites):

This part of the study covered two aspects. One on the evaluation of relative potency of certain insecticides for the extermination of mound inhabiting colony of *Odontotermes obeses* (Rambur) and the other to assess the extent of feasibility of this method for the protection of wheat crop from its ravages.

Three experimental sites namely, Durgapura, Manoharpur and Shahpura villages in district Jaipur were selected to conduct these experiments during 1978-79 and 1979-80. The radii and heights of various mounds, respectively ranged between 36 to 70 cm and 42 to 102 cm at Durgapura, 30 to 76 cm and 41 to 98 cm at Manoharpur, and 27 to 65 cm and 45 to 94 cm at Shahpura villages. Considering the mound to be near cylindrical in shape, its volume as suggested by Roonwal and Chatterjee (1960) was calculated by the formula; $V = \pi r^2 h$, where V = volume, r = radius and h = height of the mound above ground.

To determine the optimum quantity of water for drenching the mound, a pilot test was done at the Horticulture garden, Agricultural Research Station, Durgapura, Jaipur before initiating the main experiment. Aldrin 0.025 per cent emulsion was prepared to apply at the rate of 10, 20, 30 and 40 litres per cubic metre of mound volume. Tops of the mound towers were broken and the mound was also scrapped from all the directions to expose the tunnels. Later on three termitaria with each dosage of the emulsion were drenched directly into the holes with the help of a foot sprayer by inserting the spray lance (without nozzel). This operation was followed by plugging of the holes with moist soil. On the basis of further observations on the fate of the colonies a dosage of 30 litres of emulsion per cubic metre of mound volume was found to be optimum.

The insecticides tested were emulsifiable concentrates of aldrin 30 e.c., chlordane 20 e.c., heptachlor 20 e.c., lindane 20 e.c., and a granular formulation of phorate 10 G, applied at the rate of 20, 30, 30, 30 ml and 50 g, respectively, per cubic metre of mound volume (Table 39). The emulsifiable concentrates were applied by diluting with 30 litres of water per cubic metre of mound volume, while the granules were applied by the following two methods. In one case the calculated amount of granules was poured into the tunnels after drenching the mound with water at the rate of 30 litres per cubic metre of volume and in the other only granules were poured. Each site formed a replication with seven treatments including the check where only water was drenched into the mound. Three to five live mounds were assigned for each treatment.

After five weeks of the treatment and again after two months the mounds were examined and the number of live and dead colonies was recorded. Absence of living individuals (workers and soldiers) inside the mound and no addition of fresh construction in the mound was considered as sufficient indication of destruction of the colony. In addition, digging up of the mound and examination of fungal gardens and a search for queen was undertaken in some cases for confirmation.

Experiment on the effect of extermination of mound inhabited termite colony on infestation in wheat crop was conducted at two locations in Manoharpur village. Each location comprised of about two to three hectares of tube-well irrigated wheat crop with a history of regular occurrence of termite damage with live mounds along the mud-walled field borders or along the field paths. At each location two stations within a radius of 25 metres from the mound were ear-marked and five observational units each measuring two metre row length were randomly marked. During, December 1978 and March 1979 observations on per cent plant and ear-head infestation in succession were recorded (Table 40). Before the commencement of the next crop season, aldrin 30 e.c. emulsion at the rate of 20 ml per cubic metre of mound volume was added to water at a rate of 30 litres per cubic mound volume and drenched into the mound. During 1979-80 crop season, the termite infestation was again recorded around the ear-marked stations employing the same sampling technique. Per cent reduction in crop damage was calculated by comparing with the previous season's observations.

CHAPTER IV

R E S U L T S

Adherence of powders

Relative adherence of dry pesticidal powders to wheat and barley seeds:

This test was intended to determine the relative ability of various pesticidal powders to adhere to wheat and barley seeds when applied dry at the rate of 2 kg per 100 kg seed. The chemicals used and the results obtained are summarised in Table 3. All the treatments indicated a wide divergence in the amount coated on wheat and barley seeds. Most of the chemicals formed independent groups of significance. Maximum amount of 1.382 and 1.474 kg of chlordane dust adhered to wheat and barley seeds, respectively. Similarly, a minimum quantity of 0.289 and 0.319 kg of landrin wettable powder was retained on wheat and barley seeds, respectively.

It is also evident that the grouping of wettable powder of various pesticides, dust and wettable formulation of BHC and even the two different percentages of BHC dust did not demonstrate a group hormony with respect to pesticides retention on both type of seeds. However, it was apparent that barley seed retained comparatively higher amount of powder than wheat seed.

Adherence of dry pesticidal powders to wheat and barley seeds at various concentrations:

The purpose of these tests was to examine the differentiation in the amount of pesticides retained on

TABLE 3

Relative adherence of dry pesticidal powders applied @ 2 kg/100 kg seed

Sl. No.	Pesticides	Mean amount (kg) retained on seed	
		Wheat	Barley
1.	Aldrin 5% dust	0.638	0.739
2.	BHC 5% dust	0.566	0.678
3.	BHC 10% dust	0.504	0.549
4.	BHC 50 w.p.	0.566	0.668
5.	Carbaryl 50 w.p.	0.503	0.600
6.	Chlordane 5% dust	1.382	1.474
7.	Endosulfan 4% dust	0.335	0.601
8.	Heptachlor 5% dust	0.705	0.803
9.	Isophenphos + TMTD 30:10 s.d.	0.661	0.817
10.	Landrin 50 w.p.	0.289	0.319
11.	Larvin 75 w.p.	0.833	0.992
12.	Lindane 0.65% dust	0.615	0.681
13.	Mal. + DDT + BHC 3:3:2 dust	0.623	0.678
	S.Em = ±	0.020	0.022
	C.D at 5% =	0.058	0.064

wheat and barley seeds when applied dry at the rate of 1, 2 and 4 kg per 100 kg seed. The chemicals choosen were chlordane 5 per cent, aldrin 5 per cent and BHC 10 per cent dusts which had depicted maximum or moderate adherence to wheat and barley seeds in the preceding test.

Wheat: The data given in Table 4 for wheat seed revealed significant differences in the amount of adherence among the treatments and concentrations. The amount of retention per 100 kg seed was; 0.394, 0.628 and 0.736 kg for aldrin; 0.306, 0.503 and 0.608 kg for BHC and 0.838, 1.388 and 1.533 kg for chlordane at the application rates of 1, 2 and 4 kg, respectively. The quantum of additional pesticidal coatings were, 0.234 and 0.108 kg for aldrin; 0.197 and 0.105 kg for BHC and 0.550 and 0.145 for chlordane between the application rates of 1 to 2 and 2 to 4 kg, respectively. Hence, these figures clearly indicated that the increase in the additional loading of pesticidal powders did not follow a linear pattern with the rise in application rate because a decline occurred beyond the rate of 2 kg.

Barley: The data shown in Table 5 also demonstrated significant differences in the amount of adherence among the treatments and concentrations. The amount of pesticidal coating per 100 kg seed was 0.587, 0.785 and 0.892 kg for aldrin; 0.343, 0.525 and 0.682 kg for BHC

TABLE 4

Mean amount of dry pesticidal powders retained on 100 kg seed of wheat

Sl. No.	Pesticides	APPLICATION RATES 1 kg	2 kg	4 kg	Mean of Pesticides
		AMOUNT RETAINED ON SEED IN kg			
1.	Aldrin 5% dust	0.394	0.628	0.736	0.586
2.	BHC 10% dust	0.306	0.503	0.608	0.472
3.	Chlordane 5% dust	0.838	1.388	1.533	1.253
	Mean of rates	0.513	0.840	0.959	

S.Em. for interaction = $\pm$ 0.022 C.D. at 5% = 0.064

S.Em. for pesticides/rates = $\pm$ 0.012 C.D. at 5% = 0.035

TABLE 5

Mean amount of dry pesticidal powders retained on 100 kg seed of barley

Sl. No.	Pesticides	APPLICATION RATES 1 kg	2 kg	4 kg	Mean of pesticides
		AMOUNT RETAINED ON SEED IN kg			
1.	Aldrin 5% dust	0.587	0.785	0.892	0.755
2.	BHC 10% dust	0.343	0.525	0.682	0.517
3.	Chlordane 5% dust	0.851	1.467	1.682	1.333
	Mean of rates	0.594	0.926	1.085	

S.Em. for interaction = ± 0.028 C.D. at 5% = 0.082

S.Em. for pesticides/rates = ± 0.018 C.D. at 5% = 0.052

and 0.851, 1.467 and 1.682 kg for chlordane at 1, 2 and 4 kg rates, respectively. The quantity of additional loadings were; 0.198 and 0.107 kg for aldrin, 0.182 and 0.157 for BHC and 0.616 and 0.215 kg for chlordane between the application rates of 1 to 2 and 2 to 4 kg, respectively. The increase in the additional loading with the rise in the application rate was not linear and showed similar trend of reduction beyond 2 kg rate as observed in the case of wheat.

Determination of a suitable sticking
agent for pesticidal powders:

This experiment was designed to work out the best sticker among gum arabic, methyl cellulose and soluble starch which could give maximum loading of the pesticidal dusts on wheat seed. Chlordane 5 per cent and BHC 10 per cent dusts were taken, since they had shown maximum and moderate coatings among various pesticides in dry application test.

A perusal of the data set out in Table 6 indicated an increase in the pesticidal loading per 100 kg seed at 2 and 4 kg rates of application, respectively, from 1.602 to 3.686 kg for BHC and 1.542 to 3.372 kg for chlordane with the use of gum arabic. While using methyl cellulose,

TABLE 6

Determination of a suitable sticker for the adherence of pesticidal powders

Sticking agents	Average amount (kg) of pesticidal powders adhered to 100 kg wheat seed when applied at the rate of			
	2 kg		4 kg	
	BHC 10%	Chlordane 5%	BHC 10%	Chlordane 5%
Gum arabic 2% W/V	1.602	1.542	3.686	3.372
Methyl cellulose 2% W/V	1.934	1.908	3.888	3.846
Soluble starch 2% W/V	1.446	1.394	2.974	2.844

S.Em. for interaction = ± 0.030 C.D. at 5% 0.086

Means of sticking agents		Means of pesticides		Means of rates	
Gum arabic	= 2.550	BHC 10%	= 2.588	2 kg	= 1.638
Methyl cellulose	= 2.894	Chlordane 5%	= 2.284	4 kg	= 3.436
Soluble starch	= 2.164				
S.Em.	= ± 0.016	S.Em.	= ± 0.012	S.Em.	= ± 0.012
C.D. at 5%	= 0.044	C.D. at 5%	= 0.036	C.D. at 5%	= 0.036

at 2 and 4 kg rates, respectively, BHC showed a rise in adherence from 1.934 to 3.888 kg and chlordane from 1.908 to 3.846 kg. Similar trend was observed in case of soluable starch for both these pesticides at the two rates of application.

At the application rate of 2 kg with the use of gum arabic, methyl cellulose and soluable starch, respectively, BHC showed an adherence of 1.602, 1.934 and 1.446 kg, whereas chlordane showed 1.542, 1.908 and 1.394 kg. The adherence at 4 kg rate by using gum arabic, methyl cellulose and soluable starch, respectively, was 3.686, 3.888 and 2.974 for BHC and 3.372, 3.846 and 2.844 for chlordane. Both the pesticides at 2 kg rate with each kind of sticker did not depict any significant difference. Both these pesticides at 4 kg rate behaved in the same manner with methyl cellulose only. But the use of gum arabic and soluable starch gave 3.686 and 3.372 kg, and 2.974 and 2.844 kg adherence of BHC and chlordane, respectively. Both these dusts thus with each sticker were significantly different.

Irrespective of the dry adherence ability of a pesticide each sticker according to its relative strength brought about a uniform amount of loading at lower dosage. The same trend was noted at higher dosage with methyl cellulose only. Among the three stickers, significant when used with sticker. The rest of the pesticides did not induce any adverse effect when used with stickers. Seed treatment with aldrin, BHC 5 per cent, heptachlor, endosulfan, isophenphos + TMTD, larvin and malathion + DDT + BHC dusts gave hundred per cent germination at all the rates.

Emulsifiable concentrates:

Wheat: A perusal of observations laid out in Table 9 indicated 100.0, 100.0, 99.0, 99.0 and 98.5 per cent germination in aldrin, endosulfan, isophenphos, malathion + DDT + BHC and heptachlor treatments, respectively, at the dosage of 80 g a.i. which was at par with control (99.7 per cent). The dosage of 120 g a.i. gave 99.9, 99.0, 99.0, 99.0 and 100.0 per cent in aldrin, endosulfan, isophenophos, malathion + DDT + BHC and control, respectively, but rest of the treatments significantly restrained the germination as compared to control. At the rate of 160 g a.i., aldrin endosulfan, isophenphos and malathion + DDT + BHC alongwith the control formed the same group of significance showing 99.0, 99.0, 98.5, 99.7 and 99.7 per cent germination, respectively, while the remaining pesticides were inferior with respect to control. The highest dosage of 200 g a.i. impaired germination in all the treatments with the exception of malathion + DDT + BHC pesticide in comparison to control.

TABLE 9

Mean per cent germination of wheat in pots following seed treatment with emulsifiable concentrates

Sl. No.	Pesticides	APPLICATION RATES g a.i.								Mean of Pesticides	
		80		120		160		200			
1.	Aldrin	100.0	(90.00)	99.9	(88.56)	99.0	(84.23)	97.1	(80.12)	99.4	(85.73)
2.	Chlordane	96.3	(78.90)	80.1	(63.49)	65.0	(53.75)	58.0	(49.62)	77.1	(61.44)
3.	Chlorpyriphos	92.2	(73.83)	80.1	(63.49)	68.0	(55.57)	50.1	(45.00)	74.2	(59.47)
4.	Endosulfan	100.0	(90.00)	99.0	(84.23)	99.0	(84.23)	98.5	(83.00)	99.3	(85.36)
5.	Heptachlor	98.5	(83.00)	94.2	(76.01)	86.3	(68.29)	68.0	(55.57)	89.1	(70.72)
6.	Isophenphos	99.0	(84.23)	99.0	(84.23)	98.5	(83.00)	88.3	(69.99)	97.2	(80.36)
7.	Lindane	85.2	(67.33)	68.0	(55.57)	48.0	(43.85)	19.0	(25.76)	55.5	(48.13)
8.	Mal. + DDT + BHC 25:15:10	99.0	(84.23)	99.0	(84.23)	98.5	(83.00)	99.0	(84.23)	98.9	(83.92)
9.	Phenthoate	95.1	(77.24)	91.0	(72.61)	78.2	(62.14)	65.1	(53.78)	84.0	(66.44)
10.	Phoxim	94.2	(76.10)	84.1	(66.50)	72.0	(58.08)	55.0	(47.88)	78.2	(62.14)
11.	Control	99.7	(87.11)	100.0	(90.00)	99.7	(87.11)	100.0	(90.00)	100.0	(88.55)
	Mean of rates	97.6	(81.09)	93.6	(75.36)	87.6	(69.39)	78.3	(62.27)		

S.Em. for interaction = ± 2.31 C.D. at 5% = 6.42

S.Em. for pesticides = ± 1.16 C.D. at 5% = 3.21

S.Em. for rates = ± 0.70 C.D. at 5% = 1.94

Some of the pesticides were detrimental to germination at all the four dosages. Chlordane allowed 96.3, 80.1, 65.0 and 58.0 per cent., chlorpyriphos gave 92.2, 80.1, 68.0 and 50.1 per cent., lindane permitted 85.2, 68.0, 48.0 and 19.0 per cent., phenthoate depicted 95.1, 91.0, 78.2 and 65.1 per cent and phoxim displayed 94.2, 84.1, 72.0 and 55.0 per cent germination at 80, 120, 160 and 200 g a.i. rates, respectively. Seed treatment with aldrin, endosulfan, isophenphos and malathion + DDT + BHC were not found to have any inhibitory effect on germination when applied upto the dosage of 160 g a.i.

<u>Barley</u>: An examination of Table 10 depicted normal germination in all the treatments excluding lindane at the lowest applied dosage. Similar trend was also evident at the next higher dosage. At the application rate of 160 g a.i. the germination in endosulfan, malathion + DDT + BHC, aldrin, heptachlor, chlordane and isophenphos treatments being 100.0, 100.0, 99.0, 99.7, 99.7 and 99.7 per cent, respectively, was as good as in control (100.0). The application of 200 g a.i. dosage showed 99.0, 99.0, 99.0 and 99.0 per cent germination, respectively, in aldrin, endosulfan, isophenphos and malathion + DDT + BHC pesticides and was at par with control (99.7 per cent).

TABLE 10

Mean per cent germination of barley in pots following seed treatment with emulsifiable concentrates

Sl. No.	Pesticides	APPLICATION RATES g a.i.								Mean of Pesticides	
		80		180		160		200			
1.	Aldrin	100.0	(90.00)	100.0	(90.00)	99.9	(88.56)	99.9	(88.56)	100.0	(89.28)
2.	Chlordane	100.0	(90.00)	99.7	(87.11)	99.7	(87.11)	85.0	(67.25)	96.5	(82.87)
3.	Chlorpyriphos	100.0	(90.00)	99.7	(87.11)	74.1	(59.42)	69.0	(56.19)	91.6	(73.18)
4.	Endosulfan	100.0	(90.00)	100.0	(90.0)	100.0	(90.00)	99.0	(84.23)	99.9	(88.56)
5.	Heptachlor	100.0	(90.00)	99.0	(84.23)	99.7	(87.11)	89.2	(70.82)	98.5	(83.04)
6.	Isophenphos	100.0	(90.00)	100.0	(90.00)	99.7	(87.11)	99.0	(84.23)	99.9	(87.83)
7.	Lindane	96.0	(78.46)	94.2	(76.01)	71.1	(57.47)	60.1	(50.80)	83.1	(65.69)
8.	Mal. + DDT + BHC 25:15:10	100.0	(90.00)	100.0	(90.00)	100.0	(90.00)	99.0	(84.23)	99.9	(88.56)
9.	Phenthoate	100.0	(90.00)	99.7	(87.11)	99.0	(84.23)	74.1	(59.42)	97.1	(80.19)
10.	Phoxim	100.0	(90.00)	98.5	(83.00)	85.2	(67.33)	75.2	(60.16)	93.4	(75.12)
11.	Control	100.0	(90.00)	99.7	(87.11)	100.0	(90.00)	99.7	(87.11)	99.9	(88.56)
	Mean of rates	100.0	(88.95)	99.6	(86.52)	97.4	(80.76)	90.5	(72.09)		

S.Em. for interaction = ± 1.74 C.D. at 5% = 4.83

S.Em. for pesticides = ± 0.87 C.D. at 5% = 2.41

S.Em. for rates = ± 0.53 C.D. at 5% = 1.46

Retarded germination by 4.0, 5.5, 28.9 and 39.6 per cent was caused by lindane with the application of 80, 120, 160 and 200 g a.i. dosages, in sequence, as compared to their respective controls. A decline of 5.1, 10.0, 11.0 and 24.9 per cent germination was produced with the increase of dosage from 160 to 200 g a.i. in chlorpyriphos, phoxim, lindane and phenthoate seed treatments, respectively.

In general, most of the treatments did not harm germination and even at the highest dosage, aldrin, endosulfan, isophenphos and malathion + DDT + BHC were not unfavourable to germination.

Effect on mean emergence period

Powder formulations:

Wheat: It is evident from Table 11 that out of thirteen pesticides tested, four of them namely, BHC 10 per cent dust, carbaryl, landrin and BHC wettable powders applied at the rate of 2 kg dry showed the duration of emergence as 5.25, 6.13, 6.15 and 6.25 days, respectively, which was significantly less in contrast to 4.51 days of control. The period of emergence further increased in these treatments with the use of 2 kg powder with sticker. In addition BHC, heptachlor and chlordane 5 per cent dusts also demonstrated significant delay in the period of emergence as compared with control. The dosage of 4 kg

TABLE 11

Mean emergence period (days) of wheat following seed treatment with powder formulations

Sl. No.	Pesticides	APPLICATION RATES AS			Mean of pesticides
		2 kg dry	2 kg with sticker	4 kg with sticker	
1.	Aldrin 5% dust	4.25	4.33	4.80	4.46
2.	BHC 5% dust	4.51	5.48	6.12	5.37
3.	BHC 10% dust	5.25	5.98	6.63	5.95
4.	BHC 50 w.p.	6.25	7.00	7.68	6.98
5.	Carbaryl 50 w.p.	6.13	6.91	7.46	6.83
6.	Chlordane 5% dust	4.82	5.41	6.38	5.54
7.	Endosulfan 4% dust	4.45	4.51	5.10	4.69
8.	Heptachlor 5% dust	4.63	5.03	6.03	5.23
9.	Isophenphos + TMTD 30:10 s.d.	4.40	4.61	5.21	4.74
10.	Landrin 50 w.p.	6.15	7.06	7.76	6.99
11.	Larvin 75 w.p.	4.36	4.62	5.25	4.74
12.	Lindane 0.65% dust	4.33	4.51	5.08	4.64
13.	Mal.+DDT+BHC 3:3:2 dust	4.36	4.72	5.71	4.93
14.	Control	4.51	4.40	4.56	4.49
	Mean of rates	4.88	5.33	5.98	

S.Em. for interaction = $\pm$ 0.20   C.D. at 5% = 0.55

S.Em. for pesticides = $\pm$ 0.12   C.D. at 5% = 0.33

S.Em. for rates = $\pm$ 0.04   C.D. at 5% = 0.11

with sticker disclosed that aldrin and lindane dusts did not cause significant delay in emergence from control, since the durations taken were 4.80, 5.08 and 4.56 days, respectively. The remaining pesticides had pronounced adverse effect on emergence. Aldrin and lindane dusts at all the application rates allowed as good emergence as in control.

The differential increase in duration of emergence between 2 kg dry and 2 kg with sticker application was 0.73 days for BHC 10 per cent dust, 0.75 days for BHC wettable powder, 0.78 days for carbaryl wettable powder and 0.91 days for landrin wettable powder. In between 2 and 4 kg with sticker dosages the additional period in emergence consumed was 0.65, 0.55, 0.68 and 0.70 days due to the treatment of BHC 10 per cent dust, carbaryl, BHC and landrin wettable powders, respectively.

The worst effect at the three dosages of application was induced by wettable powders of BHC, carbaryl and landrin and BHC 10 per cent dust. No adverse effect on emergence was caused by aldrin, endosulfan and lindane at all the dosages.

<u>Barley</u>: The emergence in all the treatments but BHC and landrin wettable powders was nearly as quick as in control when pesticides were applied at the rate of 2 kg without sticker (Table12). The seedlings

TABLE 12

Mean emergence period (days) of barley following seed treatment with powder formulations

Sl. No.	Pesticides	APPLICATION RATES AS 2 kg dry	2 kg with sticker	4 kg with sticker	Mean of pesticides
1.	Aldrin 5% dust	4.25	4.20	4.35	4.27
2.	BHC 5% dust	4.25	4.40	4.51	4.39
3.	BHC 10% dust	4.35	4.51	5.17	4.68
4.	BHC 50 w.p.	4.85	5.52	6.16	5.51
5.	Carbaryl 50 w.p.	4.60	5.30	5.80	5.23
6.	Chlordane 5% dust	4.32	4.57	4.77	4.55
7.	Endosulfan 4% dust	4.25	4.45	4.62	4.44
8.	Heptachlor 5% dust	4.30	4.50	4.70	4.50
9.	Isophenphos + TMTD 30:10 s.d.	4.20	4.30	4.81	4.44
10.	Landrin 50 w.p.	4.90	5.60	6.38	5.63
11.	Larvin 75 w.p.	4.30	4.32	4.65	4.42
12.	Lindane 0.65% dust	4.20	4.35	4.51	4.35
13.	Mal.+DDT+BHC 3:3:2 dust	4.30	4.42	4.74	4.79
14.	Control	4.22	4.25	4.31	4.26
	Mean of rates	4.38	4.62	4.96	

S.Em. for interaction = ± 0.19 C.D. at 5% = 0.50

S.Em. for pesticides = ± 0.11 C.D. at 5% = 0.30

S.Em. for rates = ± 0.03 C.D. at 5% = 0.10

appeared significantly late in BHC, carbaryl and landrin wettable powder treatments due to the application of pesticides at 2 and 4 kg rates with sticker. Moreover, BHC 10 per cent dust also prolonged emergence period at the latter rate. A gradient of enhanced period of emergence occurred with the use of powders as 2 kg dry, 2 and 4 kg with sticker, from 4.85 to 5.52 to 6.16 days in BHC wettable powder; from 4.60 to 5.30 to 5.80 days in carbaryl wettable powder and from 4.90 to 5.60 to 6.38 days in landrin wettable powder treatments, respectively. Any remarkable variations of lateness in the appearance of seedlings did not occur in aldrin, BHC, chlordane and heptachlor 5 per cent dusts, endosulfan, lindane, malathion + DDT + BHC dusts, isophenphos + TMTD, and larvin wettable powder on account of various rates of application.

In brief, belated emergence was noticed in landrin and BHC wettable powder treatments at the three rates of application and in carbaryl at 2 and 4 kg dosages with sticker.

Emulsifiable concentrates:

<u>Wheat</u>: The data obtained (Table 13) at the application rate of 80 g a.i. indicated that the emergence period in aldrin, chlordane, endosulfan, heptachlor, isophenphos, and malathion + DDT + BHC treatments being

TABLE 13

Mean emergence period (days) of wheat following seed treatment with emulsifiable concentrates

Sl. No.	Pesticides	APPLICATION RATES IN g. a.i.				Mean of pesticides
		80	120	160	200	
1.	Aldrin	4.50	4.60	4.80	5.39	4.82
2.	Chlordane	4.72	5.42	6.00	6.61	5.69
3.	Chlorpyriphos	5.05	5.58	6.31	6.97	5.98
4.	Endosulfan	4.55	4.65	4.89	5.44	4.88
5.	Heptachlor	4.60	5.25	5.81	6.48	5.54
6.	Isophenphos	4.58	4.55	4.85	5.21	4.80
7.	Lindane	5.87	6.20	6.85	7.19	6.53
8.	Mal. + DDT + BHC 25:15:10	4.66	4.75	4.85	5.57	4.96
9.	Phenthoate	4.89	5.50	6.00	6.53	5.73
10.	Phoxim	4.99	5.86	6.13	6.90	5.97
11.	Control	4.52	4.48	4.61	4.48	4.52
	Mean of rates	4.81	5.17	5.55	5.98	

S.Em. for interaction = $\pm$ 0.12 C.D. at 5% = 0.33

S.Em. for pesticides = $\pm$ 0.06 C.D. at 5% = 0.16

S.Em. for rates = $\pm$ 0.04 C.D. at 5% = 0.10

4.50, 4.72, 4.55, 4.60, 4.58 and 4.66 days, respectively, were comparable with control (4.52 days). At the dosage of 120 g a.i. the durations extended slightly in aldrin, endosulfan, isophenphos and malathion + DDT + BHC treatments as the figures obtained were 4.60, 4.65, 4.55 and 4.75 days, respectively, which were not significantly different from control (4.48 days). Again aldrin, isophenphos, endosulfan and malathion + DDT + BHC were not found to cause noticeable delay in emergence period as compared with control at the dosage of 160 g a.i. All the pesticides deferred the emergence of seedlings in comparison to control when the application dosage was raised from 160 to 200 g a.i.

The period of emergence was found to be positively correlated with the increasing rates of application viz. 80, 120, 160 and 200 g a.i. as the durations were 5.05, 5.58, 6.31 and 6.97 days in chlorpyriphos; 5.87, 6.20, 6.85 and 7.19 days in lindane; 4.89, 5.50, 6.00 and 6.53 days in phenthoate; and 4.99, 5.86, 6.13 and 6.90 days in phoxim treatments, respectively.

The results thus showed that very high rates of the emulsifiable concentrates caused undue delay in emergence. Of the chemicals tested only aldrin, endosulfan, isophenphos and malathion + DDT + BHC did not cause any marked delayed effect on germination at 80, 120 and 160 g a.i. dosages.

Barley: The differences in the duration of emergence were non-significant in all the treatments in comparison to control at 80 g a.i. dosage (Table 14). The rate of 120 g a.i. documented adverse effects of chlorpyriphos, lindane and phoxim treatments, as the time consumed in emergence was 4.95, 5.30 and 5.10 days in contrast to 4.20 days in control. At the dosage of 160 g a.i., chlordane, chlorpyriphos, heptachlor, lindane, phenthoate and phoxim showed significantly delayed emergence than control. All the pesticides but aldrin induced maximum delay in emergence period at the dosage of 200 g a.i. The emergence period in aldrin treatment at 80, 120, 160 and 200 g a.i. was 4.25, 4.22, 4.25 and 4.43 days, respectively, which was compromising with the normal emergence period.

The results indicated a positive correlation between the dosage and the period of emergence. In addition to aldrin which did not significantly influence emergence at any dosage, four other pesticides viz. endosulfan, heptachlor, isophenphos and malathion + DDT + BHC also made no retarding effect on emergence at the three dosages excepting 200 g a.i. dosage.

Phytotoxicity symptoms in wheat and barley seedlings caused by seed treatment with pesticides:

The non-germination of a healthy seed under optimum conditions is an indication of the extreme state of

TABLE 14

Mean emergence period (days) of barley following seed treatment with emulsifiable concentrates

Sl. No.	Pesticides	APPLICATION RATES IN g a.i.				Mean of pesticides
		80	120	160	200	
1.	Aldrin	4.25	4.22	4.25	4.43	4.29
2.	Chlordane	4.35	4.65	4.95	5.49	4.86
3.	Chlorpyriphos	4.44	4.95	5.84	6.39	5.41
4.	Endosulfan	4.25	4.20	4.57	5.16	4.54
5.	Heptachlor	4.30	4.50	4.73	5.38	4.73
6.	Isophenphos	4.28	4.46	4.65	5.31	4.67
7.	Lindane	4.71	5.30	6.00	6.44	5.61
8.	Mal.+DDT+BHC 25:15:10	4.30	4.62	4.70	5.00	4.65
9.	Phenthoate	4.35	4.55	5.00	5.40	4.83
10.	Phoxim	4.55	5.10	5.65	5.94	5.31
11.	Control	4.29	4.20	4.25	4.28	4.27
	Mean of rates	4.37	4.62	4.96	5.38	

S.Em. for interaction = $\pm$ 0.17 C.D. at 5% = 0.47

S.Em. for pesticides = $\pm$ 0.08 C.D. at 5% = 0.22

S.Em. for rates = $\pm$ 0.01 C.D. at 5% = 0.03

phytotoxicity. Some seeds affected by the pesticide wane to germinate and thus do not emerge out of the soil. An examination of the non-germinated seeds treated with some effective pesticides have shown symptoms with varied degrees of phytotoxicity. In some cases the plumule did not develop at all or after the initiation of germination the radicle and or plumule hypertrophied (Plate IV Fig. 1). In others the plumule became abnormally thick and short with normal growth of the seminal roots (Plate IV Fig. 2). Occasionally the weakly developed plumule took a curve or twist resulting in non-emergence of the seedling from the soil surface.

The following categories of phytotoxic symptoms caused by emulsion and powder formulations of certain effective pesticides have been observed in wheat and barley seedlings during green-house tests.

A. Emulsifiable concentrates

1. Chlorpyriphos (Plate V Fig. 1)

   (a) Leaf broad and leathery with prominent parallel veins. Leaf tip semi-circular and notched with a thin brown rim indicating a sort of burning effect.

   (b) Angular emergence, leathery and humped leaf.

2. Phenthoate (Plate V Fig. 1)

   (c) Leaf longitudinally folded, needle shaped, dark green with burned tip.

PLATE IV

Fig. 1 Plumule - hypertrophied

Radicle - stunted or poorly developed roots

Treatment - Lindane e.c. @ 200 g a.i./100 kg of wheat seed

Fig. 2 Plumule - hypertrophied

Roots - Normal seminal roots

Treatment - phenthoate e.c. @ 200 a.i./100 kg of wheat seed

PLATE IV

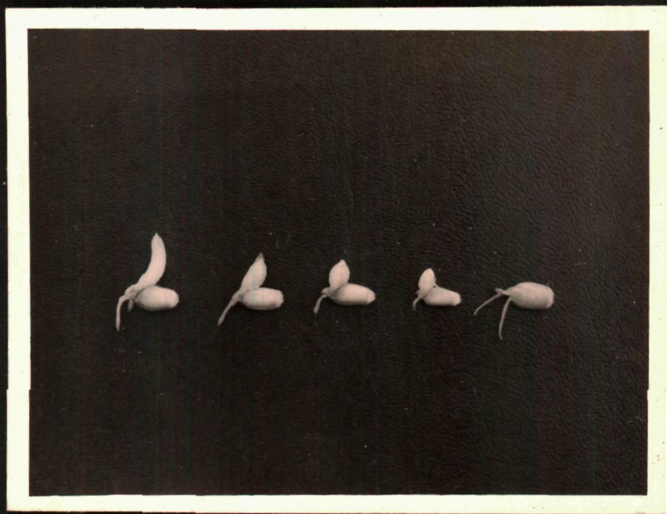


FIG.1

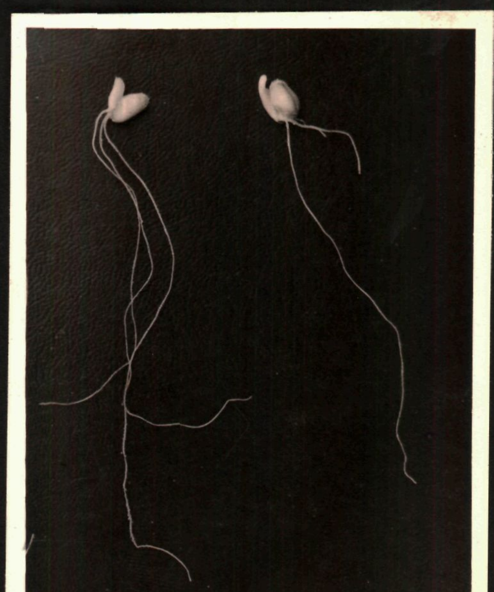


PLATE V

Fig. 1 Seedling leaf injury

Treatment - (Phe) Phenthoate - needle shaped tip and (Chl) Chloropyriphos - semicircular notched tip @ 200 g a.i./100 kg of wheat seed

(Con) untreated - normal tips

Fig. 2 Wheat seedlings - stunted

Treatment - (A) BHC 50 w.p. @ 4 kg with sticker/100 kg of wheat seed

(B) Landrin 50 w.p. @ 4 kg with sticker/100 kg of wheat seed

(C) Untreated

PLATE V

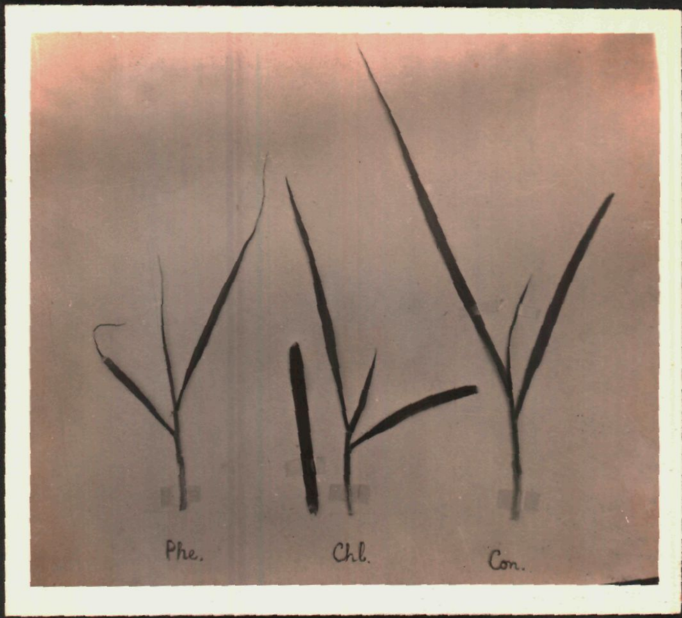


FIG. 1

FIG. 2

(d) Leaf shape and colour as in (c) but without burned tip.

3. Lindane (Plate IV Fig. 1)

(e) Radicle and plumule hypertrophied or stunted growth and thick leaves.

4. Phoxim

(f) Angular emergence and stunted growth

B. Wettable powders

1. BHC (Plate V Fig. 2)

(g) Stunted growth with white papery leaf.

(h) Stunted thick leaf with yellow longitudinal streaks or chlorotic patches

(i) Angular emergence and stunted growth.

2. Carbaryl

(j) Stunted growth, leaf with yellow streaks.

(k) Stunted growth with thick leaf.

3. Landrin (Plate V Fig. 2)

(l) Leaf completely yellow.

(m) Leaf with yellow streaks or chlorotic patches.

(N) Normal Seedlings.

The per cent seedling emergence and the frequency of various categorised phytotoxic symptoms recorded in wheat and barley seedlings due to the application of emulsifiable concentrates at the rate of 200 g a.i. and with 50 per cent wettable powders at the rate of 4 kg with sticker per 100 kg seed have been presented in plate VI and VII.

Effect on plant growth

Top height

Powder formulations:

Wheat: The observations given in Table 15 clearly indicated that BHC, carbaryl and landrin wettable powders adversely effected the shoot height at 2 kg dry application showing 6.46, 6.75 and 6.77 cm top height as compared to 10.76 cm in control. At the rate of 2 kg with sticker the wettable powders of BHC, carbaryl and landrin as well as BHC 5 and 10 per cent dusts, chlordane and heptachlor dusts showed reduced top growth. At 4 kg rate with sticker in addition to the above treatments isophenphos + TMTD and malathion + DDT + BHC also proved harmful to top growth.

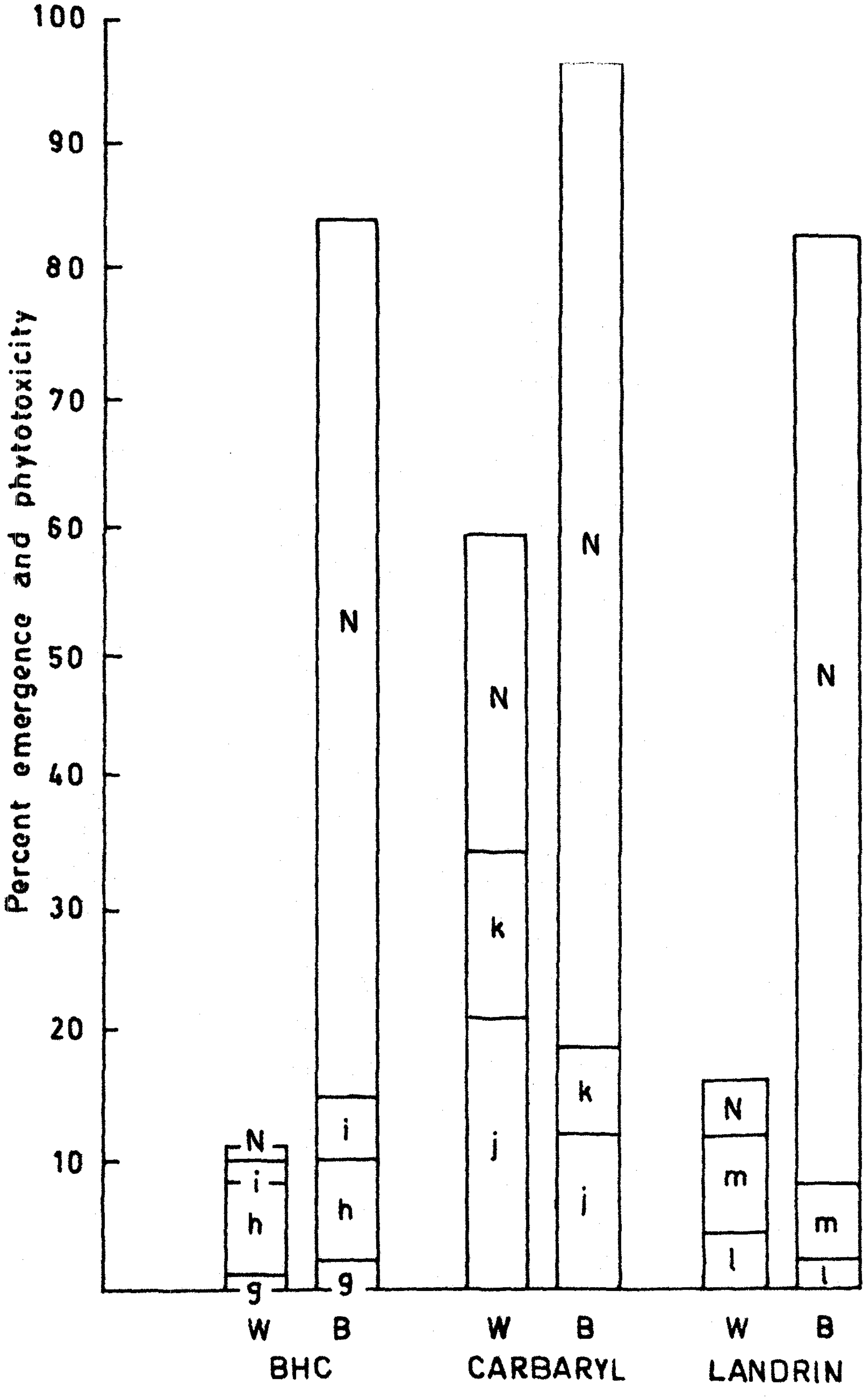
It is thus evident that application of aldrin, endosulfan, larvin and lindane did not hamper the top growth at all the tested dosages.

Barley: The top height was found to be significantly less in BHC, carbaryl and landrin wettable powder treatments being, 10.48, 11.12 and 10.36 cm with 2 kg dry application; 8.79, 9.34 and 8.59 cm in 2 kg with sticker and 7.17, 8.08 and 6.70 cm in 4 kg with sticker, respectively,

PLATE VI

Categorised phytotoxic symptoms in the emerged seedlings of wheat and barley caused by 50 per cent wettable formulations applied at the rate of 4 kg with sticker per 100 kg seed.

PLATE VI



Percent emergence and phytotoxicity
100
90
80
70
60
50
40
30
20
10
N
i
h
g
N
i
h
g
N
k
j
N
k
j
N
m
l
N
m
l
W
B
BHC
W
B
CARBARYL
W
B
LANDRIN

PLATE VII

Categorised phytotoxic symptoms in the emerged seedlings of wheat and barley caused by emulsifiable formulations applied at the rate of 200 g a.i. per 100 kg seed.

PLATE VII

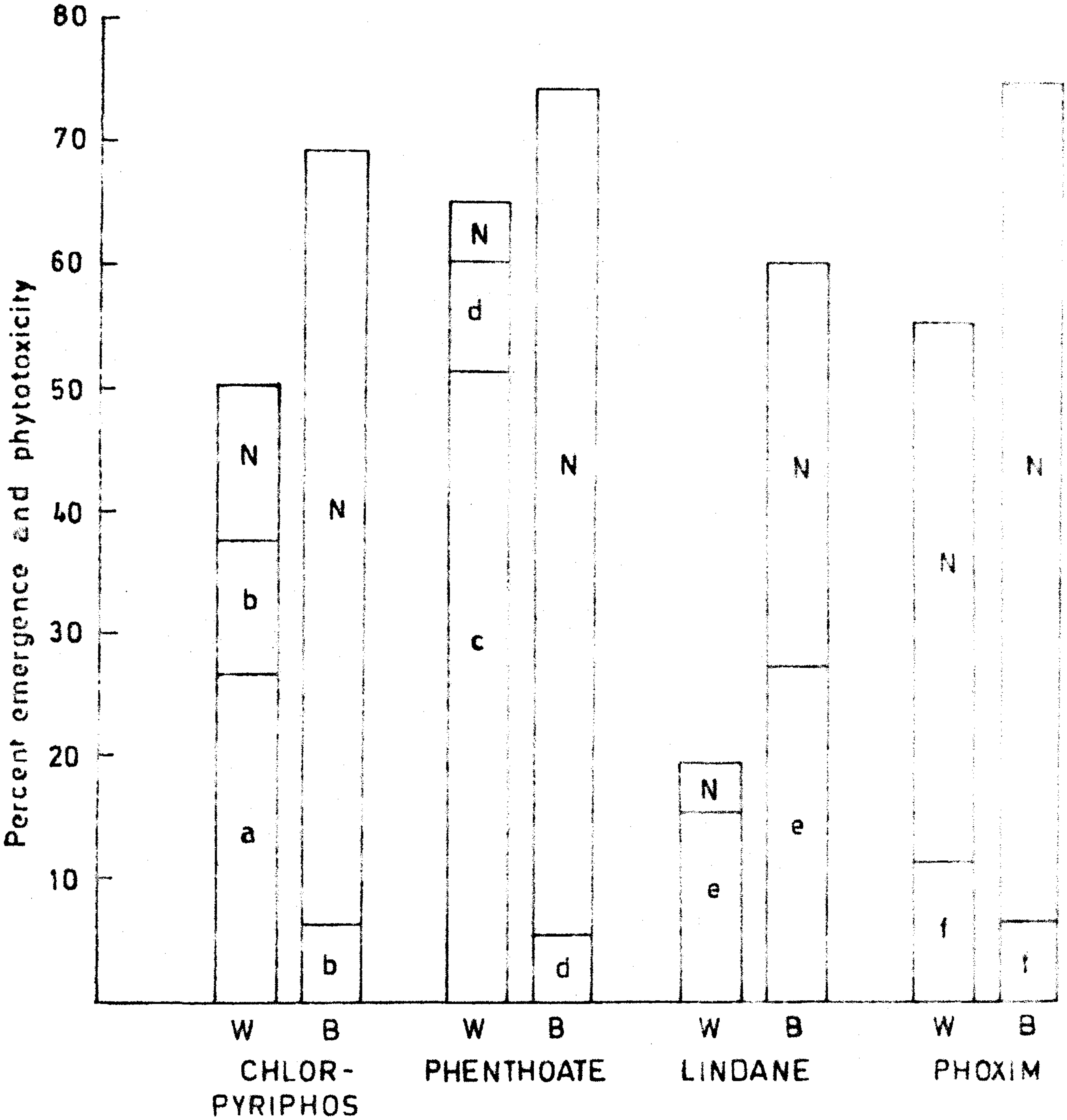

80
70
60
50
40
30
20
10
Percent emergence and phytotoxicity
N
b
a
N
b
N
d
c
N
d
N
e
N
e
N
f
N
f
W
B
W
B
W
B
W
B
CHLOR-
PYRIPHOS
PHENTHOATE
LINDANE
PHOXIM

TABLE 15

Mean top height (cms) of wheat following seed treatment with powder formulations

Sl. No.	Pesticides	APPLICATION RATES AS			Mean of pesticides
		2 kg dry	2 kg with sticker	4 kg with sticker	
1.	Aldrin 5% dust	10.66	10.75	10.44	10.62
2.	BHC 5% dust	10.10	9.23	8.16	9.16
3.	BHC 10% dust	9.80	8.25	6.48	8.18
4.	BHC 50 w.p.	6.46	4.70	3.41	4.86
5.	Carbaryl 50 w.p.	6.75	4.91	3.61	5.09
6.	Chlordane 5% dust	10.00	9.22	8.22	9.15
7.	Endosulfan 4% dust	10.71	10.56	9.80	10.36
8.	Heptachlor 5% dust	10.28	9.35	8.29	9.31
9.	Isophenphos + TMTD 30:10 s.d.	10.81	10.33	9.63	10.26
10.	Landrin 50 w.p.	6.77	4.64	3.08	4.83
11.	Larvin 75 w.p.	10.80	10.31	9.82	10.31
12.	Lindane 0.65% dust	10.44	10.20	9.95	10.20
13.	Mal.+DDT+BHC 3:3:2 dust	9.99	10.00	9.74	9.91
14.	Control	10.76	10.60	10.65	10.67
	Mean of rates	9.59	8.79	7.95	

S.Em. for interaction = $\pm$ 0.32 C.D. at 5% = 0.88

S.Em. for pesticides = $\pm$ 0.18 C.D. at 5% = 0.50

S.Em. for rates = $\pm$ 0.08 C.D. at 5% = 0.22

while their respective controls had top lengths of 12.07, 11.96 and 11.87 cm (Table 16). In addition BHC 10 per cent dust at 4 kg rate with sticker also reduced top growth significantly from the control. Other treatments at the dosages of 2 kg dry, 2 kg and 4 kg with stickers produced non-significant variation in comparison to their respective controls with respect to top heights which ranged between 11.75 to 12.13, 11.34 to 11.88 and 11.15 to 11.85 cm, respectively.

The pesticides which did not cause any pronounced difference in top heights at any of the tested dosages were; aldrin, BHC 5 per cent dust, chlordane, endosulfan, heptachlor, isophenphos + TMTD, lindane, malathion,+ DDT + BHC dusts and larvin wettable powder.

Emulsifiable concentrates:

Wheat: The data given in Table 17 demonstrated the adverse effect of chlorpyriphos, lindane and phoxim at all the application rates and also of chlordane, heptachlor and phenthoate at 120 and 160 g a.i. dosages. At the highest concentration all the treatments significantly retarded the top growth. Further, the treatments also showed a progressive reduction of top growth in most of the treatments e.g. lindane gave 7.21, 6.45, 4.95 and 4.16 cm top length at 80, 120, 160 and 200 g a.i. respectively.

TABLE 16

Mean top height (cms) of barley following seed treatment with powder formulations

Sl. No.	Pesticides	APPLICATION RATES AS			Mean of pesticides
		2 kg dry	2 kg with sticker	4 kg with sticker	
1.	Aldrin 5% dust	12. 00	11.83	11.75	11.86
2.	BHC 5% dust	12.00	11.62	11.34	11.65
3.	BHC 10% dust	11.75	11.34	9.67	10.92
4.	BHC 50 w.p.	10.48	8.79	7.17	8.81
5.	Carbaryl 50 w.p.	11.12	9.34	8.08	9.51
6.	Chlordane 5% dust	11.82	11.44	11.20	11.49
7.	Endosulfan 4% dust	12.00	11.49	11.36	11.62
8.	Haptachlor 5% dust	11.86	11.37	11.15	11.46
9.	Isophenphos+TMTD 30:10 s.d.	12.13	11.88	11.17	11.73
10.	Landrin 50 w.p.	10.36	8.59	6.70	8.55
11.	Larvin 75 w.p.	11.90	11.88	11.35	11.71
12.	Lindane 0.65% dust	12.12	11.75	11.85	11.91
13.	Mal.+DDT+BHC 3:3:2 dust	11.67	11.57	11.26	11.57
14.	Control	12.07	11.96	11.87	11.97
	Mean of rates	11.68	11.06	10.42	

S.Em. for interaction = ± 0.26 C.D. at 5% = 0.72

S.Em. for pesticides = ± 0.14 C.D. at 5% = 0.39

S.Em. for rates = ± 0.06 C.D. at 5% = 0.17

TABLE 17

Mean top height (cms) of wheat following seed treatment with emulsifiable concentrates

Sl. No.	Pesticides	APPLICATION RATES IN g a.i.				Mean of pesticides
		80	120	160	200	
1.	Aldrin	10.36	10.29	10.08	9.58	10.08
2.	Chlordane	9.86	8.24	6.91	5.51	7.63
3.	Chlorpyriphos	9.10	7.23	6.19	4.67	6.80
4.	Endosulfan	10.25	10.02	9.85	8.19	9.58
5.	Heptachlor	10.13	8.63	7.35	5.79	7.98
6.	Isophenphos	10.18	10.00	9.90	7.88	9.49
7.	Lindane	7.21	6.45	4.95	4.16	5.69
8.	Mal.+DDT+BHC 25:15:10	10.00	9.88	9.96	7.90	9.43
9.	Phenthoate	9.67	8.06	6.91	5.67	7.58
10.	Phoxim	9.23	7.88	6.61	4.83	7.14
11.	Control	10.29	10.41	10.57	10.41	10.42
	Mean of rates	9.66	8.83	8.12	6.78	

S.Em. for interaction = ± 0.26 C.D. at 5% = 0.72

S.Em. for pesticides = ± 0.13 C.D. at 5% = 0.36

S.Em. for rates = ± 0.08 C.D. at 5% = 0.22

Aldrin, endosulfan, isophenphos and malathion + DDT + BHC in concentrations ranging from 80 to 160 g a.i. appeared safe for use as they did not exhibit any adverse effect on top height.

Barley: The top growth in all the treatments fell in line with control at the application rate of 80 g a.i. (Table 18). However, top height was affected at 120 g a.i. giving 9.23 and 10.11 cm lengths in lindane and phoxim treatments, respectively, whereas in control it was 11.88 cm. At 160 g a.i. dosage, aldrin, endosulfan, isophenphos and malathion + DDT + BHC treatments allowed the top to become 11.73, 10.97, 10.81 and 10.96 cm long, respectively, which were at par with control (11.86 cm). The remaining treatments reduced top growth significantly inferior to control. The application at the rate of 200 g a.i. did not check the top prolongation in aldrin and malathion + DDT + BHC treatments since it was 11.85 and 10.66 cm, respectively, in comparison to 11.75 cm in control. Aldrin and malathion + DDT + BHC at all the dosages gave top growth ranging between 11.73 to 11.94 cm and 10.66 to 11.74 cm, respectively.

In general, a direct correlation of reduction in top growth was observed with a rise in concentration of the chemical, the lower dosages being safe for the seed

TABLE 18

Mean top height (cms) of barley following seed treatment with emulsifiable concentrates

Sl. No.	Pesticides	APPLICATION RATES IN g a.i.				Mean of pesticides
		80	120	160	200	
1.	Aldrin	11.86	11.94	11.73	11.85	11.84
2.	Chlordane	11.62	11.20	10.61	9.76	10.80
3.	Chlorpyriphos	11.12	10.74	7.89	7.52	9.32
4.	Endosulfan	11.86	11.99	10.97	10.50	11.33
5.	Heptachlor	11.74	11.24	10.66	10.04	10.92
6.	Isophenphos	11.79	11.34	10.81	10.22	11.04
7.	Lindane	10.72	9.23	7.49	7.29	8.68
8.	Mal.+DDT+BHC 25:15:10	11.74	10.94	10.96	10.66	11.07
9.	Phenthoate	11.62	11.11	9.98	9.98	10.67
10.	Phoxim	11.39	10.11	8.36	8.00	9.46
11.	Control	11.69	11.88	11.86	11.75	11.80
	Mean of rates	11.56	11.06	10.12	9.78	

S.Em. for interaction = $\pm$ 0.42 C.D. at 5% = 1.16

S.Em. for pesticides = $\pm$ 0.21 C.D. at 5% = 0.58

S.Em. for rates = $\pm$ 0.12 C.D. at 5% = 0.33

treatment. Taking the over-all efficacy in view the treatments with aldrin and malathion + DDT + BHC were innocuous to the growth at all dosages.

Dry seedling weight

Powder formulations:

Wheat: The perusal of data given in Table 19 revealed significant reduction in plant weight in treatments with wettable powders of BHC, carbaryl and landrin, and BHC 10 per cent and chlordane dusts at 2 kg dry application giving 17.08, 17.85, 17.90, 24.85 and 26.73 mg as compared to 30.00 mg in control. At the rate of 2 kg with sticker, all the treatments except aldrin, endosulfan, isophenphos + TMTD, larvin and lindane inhibited seedling weight, while at 4 kg rate with sticker only aldrin endosulfan, larvin and lindane did not prove harmful.

In general, only aldrin endosulfan larvin and lindane at all the dosages were safer for use as they did not deter the weight significantly in comparison to control.

Barley: A survey of the observations set out in Table 20 reflected non-significant variations in weights ranging from 33.23 to 33.63 mg in aldrin, 31.70 to 33.53 mg in BHC 5 per cent, 31.90 to 33.08 mg in chlordane, 31.95 to 33.70 mg in endosulfan, 31.70 to 33.15 mg in heptachlor, 31.70 to 33.93 mg in isophenphos + TMTD,

TABLE 20

Mean seedling dry weight (mgs) of barley following seed treatment with powder formulations

Sl. No.	Pesticides	APPLICATION RATES AS			Mean of pesticides
		2 kg dry	2 kg with sticker	4 kg with sticker	
1.	Aldrin 5% dust	33.63	33.23	33.55	33.47
2.	BHC 5% dust	33.53	32.45	31.70	32.56
3.	BHC 10% dust	32.83	31.70	30.05	31.53
4.	BHC 50 w.p.	29.40	24.53	21.05	24.99
5.	Carbaryl 50 w.p.	31.13	26.70	22.55	26.79
6.	Chlordane 5% dust	33.08	31.35	31.90	32.11
7.	Endosulfan 4% dust	33.70	32.13	31.95	32.59
8.	Heptachlor 5% dust	33.15	31.70	31.86	32.24
9.	Isophenphos + TMTD 30:10 s.d.	33.93	33.23	31.70	32.95
10.	Landrin 50 w.p.	29.85	24.03	18.73	24.20
11.	Larvin 75 w.p.	33.63	33.13	31.80	32.85
12.	Lindane 0.65% dust	33.85	32.80	31.90	32.85
13.	Mal.+DDT+BHC 3:3:2 dust	33.20	32.35	32.00	32.52
14.	Control	33.70	33.43	34.10	33.74
	Mean of rates	32.76	30.91	29.63	

S.Em. for interaction = ± 0.87 C.D. at 5% = 2.41

S.Em. for pesticides = ± 0.48 C.D. at 5% = 1.33

S.Em. for rates = ± 0.20 C.D. at 5% = 0.55

31.80 to 33.63 mg in larvin, 31.90 to 33.85 mg in lindane and 32.00 to 33.20 in malathion + DDT + BHC, under pesticidal application rates of 2 kg dry, 2 and 4 kg with sticker. Significantly lesser weights than control ranging betwixt 21.05 to 29.40 mg, 22.55 to 31.13 mg and 18.73 to 29.85 mg were obtained in wettable powders of BHC, carbaryl and landrin, respectively, with the three rates of application.

Of all the tested pesticides, aldrin, BHC 5 per cent, chlordane, endosulfan, heptachlor, isophenphos + TMTD, larvin, lindane and malathion + DDT + BHC appeared suitable because they did not exhibit any marked reduction in weight.

Emulsifiable concentrates:

Wheat: A study of Table 21 indicated that the seedling weights were significantly less viz., 24.60, 19.13 and 25.30 mg in chlorpyriphos, lindane and phoxim treatments, respectively, than control (27.95 mg) at 80 g a.i. At 120 g a.i. rate a decline in weights was also observed in chlordane (22.33 mg), chlorpyriphos (20.20 mg), heptachlor (23.20 mg), lindane (17. 08 mg), phenthoate (21.55 mg) and phoxim (21.08 mg) as compared to control (26.00 mg). Aldrin and endosulfan were the only pesticides which were not inferior to control at 160 g a.i. dosage but at 200 g a.i. all the pesticides

TABLE 21

Mean seedling dry weight (mgs) of wheat following seed treatment with emulsifiable concentrates

Sl. No.	Pesticides	APPLICATION RATES IN g a.i. 80	120	160	200	Mean of pesticides
1.	Aldrin	27.83	27.95	26.78	25.53	27.02
2.	Chlordane	26.55	22.33	18.38	14.48	20.43
3.	Chlorpyriphos	24.60	20.20	16.33	12.43	18.39
4.	Endosulfan	28.55	27.00	26.45	23.95	26.49
5.	Heptachlor	27.33	23.20	19.50	15.20	21.31
6.	Isophenphos	27.38	26.88	25.30	21.05	25.15
7.	Lindane	19.13	17.08	12.80	10.60	14.90
8.	Mal.+DDT+BHC 25:15:10	26.90	26.98	24.25	23.13	25.31
9.	Phenthoate	26.03	21.55	18.33	14.80	20.18
10.	Phoxim	25.30	21.08	17.33	12.50	19.10
11.	Control	27.95	28.00	28.40	28.13	28.12
	Mean of rates	26.14	23.84	21.26	18.34	

S.Em. for interaction = ± 0.77 C.D. at 5% = 2.13

S.Em. for pesticides = ± 0.40 C.D. at 5% = 1.11

S.Em. for rates = ± 0.10 C.D. at 5% = 0.28

markedly reduced the weight in comparison to control.

A complete view of the data disclosed that at the dosage of 160 g a.i., treatments with aldrin and endosulfan were only suitable as they did not reflect significant reduction in seedling weight from the control.

Barley: The seedling dry weights obtained in all the treatments were not poor than the control (32.85 mg) except in lindane (29.98 mg) at the application rate of 80 g a.i. (Table 22). The dosage of 120 g a.i. reduced the dry weights in chlordane, chlorpyriphos and lindane being, 30.76, 27. 20 and 25.83 mg, respectively, in comparison to control (33.13 mg). At 160 g a.i. lesser dry weights were obtained in chlordane (29.20 mg), chlorpyriphos (22.13 mg), heptachlor (28.83 mg), lindane (20.90 mg), phenthoate (27.85 mg) and phoxim (23.33 mg) treatments as compared to control (33.35 mg). The application rate of 200 g a.i. further showed dwindling in weights due to chlordane, chlorpyriphos, heptachlor, isophenphos, lindane, phenthoate and phoxim treatments by giving 27.58, 22.25, 27.20, 27.20, 18.85, 25.13 and 24.33 mg, respectively, which were significantly lower than the control (32.70 mg).

The panorama of these data proved aldrin, endosulfan and malathion + DDT + BHC treatments to be favourable for seed treatment as they did not suppress plant weight at all the tested dosages.

TABLE 22

Mean seedling dry weight (mgs) of barley following seed treatment with emulsifiable concentrates

Sl. No.	Pesticides	APPLICATION RATES IN g a.i				Mean of pesticides
		80	120	160	200	
1.	Aldrin	33.15	33.33	32.95	32.45	32.97
2.	Chlordane	32.45	30.76	29.20	27.58	30.00
3.	Chlorpyriphos	31.03	27.20	22.13	22.25	25.65
4.	Endosulfan	33.15	33.58	31.25	30.88	32.21
5.	Heptachlor	32.85	31.45	28.83	27.20	30.08
6.	Isophenphos	32.93	31.65	31.63	27.20	30.85
7.	Lindane	29.98	25.83	20.90	18.85	23.89
8.	Mal.+DDT+BHC 25:15:10	32.70	32.58	31.95	30.50	31.93
9.	Phenthoate	32.43	31.08	27.85	25.13	29.12
10.	Phoxim	31.83	30.91	23.33	24.33	27.60
11.	Control	32.85	33.13	33.35	32.70	33.01
	Mean of rates	32.30	31.04	28.49	27.19	

S.Em. for interaction = ± 0.82 C.D. at 5% = 2.27

S.Em. for pesticides = ± 0.40 C.D. at 5% = 1.11

S.Em. for rates ± 0.28 C.D. at 5% = 0.78

Field trials (microplot tests)

Effect on germination

Powder formulations:

Wheat: The observations procured, following the administration of dry pesticidal powders at the rate of 2 kg denoted significant hampering of germination with BHC 10 per cent dust and wettable powders of carbaryl, landrin and BHC giving 80.4, 76.7, 75.3 and 71.3 per cent germination, respectively, as against 89.3 per cent of control (Table 23). With the use of 2 kg powder with sticker the reduction in germination from that of control was 6.0, 9.6, 12.0, 21.7, 25.7, 41.7 and 70.0 per cent in BHC, heptachlor and chlordane 5 per cent dusts, carbaryl, BHC 10 per cent, landrin and BHC wettable powders, respectively. Further retardation of germination was seen with the application of 4 kg pesticide with sticker in most of the treatments. But no obstruction appeared in case of aldrin, endosulfan, lindane, malathion + DDT + BHC dusts and larvin wettable powder treatments which, in order, gave 87.4, 85.1, 84.0, 84.0 and 83.7 per cent germination in comparison to 87.7 per cent in control.

The over-all data revealed that BHC 10 per cent dust and wettable powders of BHC, carbaryl and landrin imposed detrimental effects on germination at all the tested dosages. There was no hampering in germination of seeds

TABLE 23

Mean per cent germination of wheat in microplots following seed treatment with powder formulations

Sl. No.	Pesticides	APPLICATION RATES AS						Mean of pesticides	
		2 kg dry		2 kg with sticker		4 kg with sticker			
1.	Aldrin 5% dust	90.0	(71.58)	88.0	(69.74)	87.4	(69.22)	88.5	(70.18)
2.	BHC 5% dust	88.0	(69.74)	84.0	(66.45)	67.0	(54.95)	80.4	(63.71)
3.	BHC 10% dust	80.4	(63.69)	64.3	(53.33)	35.0	(36.26)	60.6	(51.09)
4.	BHC 50 w.p.	71.3	(57.63)	20.0	(26.56)	4.3	(12.00)	28.2	(32.06)
5.	Carbaryl 50 w.p.	76.7	(61.12)	68.3	(55.76)	51.3	(45.76)	65.8	(54.22)
6.	Chlordane 5% dust	90.0	(71.58)	78.0	(62.06)	74.0	(59.35)	81.1	(64.33)
7.	Endosulfan 4% dust	89.7	(71.28)	86.0	(68.04)	85.1	(67.27)	87.0	(68.86)
8.	Heptachlor 5% dust	89.7	(71.28)	80.4	(63.69)	78.7	(62.50)	83.2	(65.82)
9.	Isophenphos + TMTD 30:10 s.d.	88.1	(69.81)	88.0	(69.77)	78.7	(62.53)	85.2	(67.37)
10.	Landrin 50 w.p.	75.3	(60.23)	48.3	(44.04)	39.0	(38.65)	54.6	(47.64)
11.	Larvin 75% w.p.	89.0	(70.64)	85.0	(67.22)	83.7	(66.17)	86.0	(68.01)
12.	Lindane 0.65% dust	89.7	(71.25)	87.0	(68.90)	84.0	(66.45)	87.0	(68.87)
13.	Mal. + DDT + BHC 3:3:2 dust	89.7	(71.28)	86.1	(68.09)	84.0	(66.45)	86.7	(68.60)
14.	Control	89.3	(70.94)	90.0	(71.61)	87.7	(69.49)	89.1	(70.68)
	Mean of rates	86.0	(68.00)	76.6	(61.09)	67.9	(55.50)		

S.Em. for interaction = $\pm$ 1.60 C.D. at 5% = 4.51

S.Em. for pesticides = $\pm$ 0.93 C.D. at 5% = 2.62

S.Em. for rates = $\pm$ 0.42 C.D. at 5% = 1.18

treated with aldrin, endosulfan, larvin, lindane and malathion + DDT + BHC, even at the highest dosage.

Barley: The germination on account of dry application of pesticidal powders at the rate of 2 kg was not deferred by any of the treatments in comparison to control (Table 24). The dosage of 2 kg with sticker has shown significantly low germination by 7.3, 12.0 and 16.3 per cent with wettable powders of carbaryl, BHC and landrin, respectively, from the control. Again a reduction by 9.4, 20.8 and 21.8 per cent in comparison to control was influenced by wettable treatments of carbaryl, BHC and landrin, respectively, at the rate of 4 kg with sticker. Besides these treatments, BHC 10 per cent dust also gave 12.1 per cent reduction in germination at this dosage.

Out of all these treatments, aldrin and larvin were the best followed by BHC 5 per cent dust, chlordane, endosulfan, heptachlor, isophenphos + TMTD, lindane and malathion + DDT + BHC as they did not impair germination in comparison to control.

Emulsifiable concentrates:

Wheat: The observations furnished in Table 25 stated the adverse effect of lindane, chlorpyriphos, phenthoate and phoxim treatments indicating 64.0, 65.3, 69.3, and 71.3 per cent in control at 80 g a.i. dosage.

TABLE 24

Mean per cent germination of barley in microplots following seed treatment with powder formulations

Sl. No.	Pesticides	APPLICATION RATES AS						Mean of pesticides	
		2 kg dry		2 kg with sticker		4 kg with sticker			
1.	Aldrin 5% dust	91.0	(72.59)	90.1	(71.66)	89.4	(70.96)	90.2	(71.74)
2.	BHC 5% dust	90.0	(71.58)	90.1	(71.62)	88.0	(69.74)	89.4	(70.98)
3.	BHC 10% dust	90.4	(71.92)	88.0	(69.74)	80.0	(63.44)	86.4	(68.37)
4.	BHC 50 w.p.	88.7	(70.38)	78.0	(62.04)	71.3	(57.64)	79.9	(63.35)
5.	Carbaryl 50 w.p.	89.4	(70.96)	82.7	(65.45)	82.7	(65.45)	85.1	(67.29)
6.	Chlordane 5% dust	90.0	(71.57)	86.3	(68.88)	87.0	(68.88)	88.1	(69.78)
7.	Endosulfan 4% dust	90.1	(71.62)	88.0	(69.74)	88.0	(69.74)	88.7	(70.37)
8.	Heptachlor 5% dust	89.0	(70.64)	88.0	(69.74)	87.7	(69.46)	88.2	(69.95)
9.	Isophenphos + TMTD 30:10 s.d.	90.1	(71.70)	86.0	(68.04)	87.0	(68.88)	87.8	(69.54)
10.	Landrin 50 w.p.	86.7	(68.64)	73.7	(59.14)	70.3	(57.00)	77.4	(61.60)
11.	Larvin 75 w.p.	90.7	(72.25)	90.0	(71.58)	90.1	(71.62)	90.3	(71.82)
12.	Lindane 0.65% dust	90.7	(72.22)	89.7	(71.28)	88.0	(69.74)	89.5	(71.08)
13.	Mal. + DDT + BHC 3:3:2 dust	89.7	(71.28)	89.7	(71.28)	88.0	(69.74)	89.2	(70.77)
14.	Control	91.7	(73.27)	90.0	(71.58)	92.1	(73.65)	91.3	(72.83)
	Mean of rates	89.9	(71.47)	86.8	(68.70)	85.4	(67.57)		

S.Em. for interaction = ± 1.70 C.D. at 5% = 4.79

S.Em. for pesticides = ± 0.98 C.D. at 5% = 2.76

S.Em. for rates = ± 0.44 C.D. at 5% = 1.24

TABLE 25

Mean per cent germination of wheat in microplots following seed treatment with emulsifiable concentrates

Sl. No.	Pesticides	APPLICATION RATES g a.i.								Mean of Pesticides	
		80		120		160		200			
1.	Aldrin	88.1	(69.78)	85.0	(67.22)	88.5	(70.17)	80.7	(63.93)	85.7	(67.77)
2.	Chlordane	83.1	(65.70)	68.7	(55.97)	52.3	(46.34)	52.0	(46.15)	64.4	(53.54)
3.	Chlorpyriphos	65.3	(53.93)	56.0	(48.46)	43.7	(41.36)	40.3	(39.43)	51.4	(45.79)
4.	Endosulfan	85.0	(67.22)	85.0	(67.22)	89.6	(71.13)	80.7	(63.93)	85.2	(67.37)
5.	Heptachlor	84.7	(66.96)	76.7	(61.13)	65.3	(53.93)	52.7	(46.53)	70.6	(57.14)
6.	Isophenphos	82.4	(65.18)	86.4	(68.34)	72.7	(58.48)	68.0	(55.55)	77.8	(61.88)
7.	Lindane	64.0	(53.13)	30.0	(33.20)	17.3	(24.59)	6.6	(14.90)	27.2	(31.46)
8.	Mal. + DDT + BHC 25:15:10	85.0	(67.22)	84.7	(66.96)	78.7	(62.51)	75.0	(60.00)	81.0	(64.17)
9.	Phenthoate	69.3	(56.38)	61.3	(51.55)	56.0	(48.45)	51.0	(45.57)	59.5	(50.49)
10.	Phoxim	71.3	(57.64)	65.0	(53.74)	47.7	(43.63)	43.3	(41.17)	57.1	(49.05)
11.	Control	87.7	(69.46)	89.0	(70.64)	93.3	(74.96)	88.0	(69.78)	89.6	(71.21)
	Mean of rates	79.3	(62.97)	72.8	(58.58)	65.7	(54.14)	58.2	(49.72)		

S.Em. for interaction = $\pm$ 1.72 C.D. at 5% = 4.84

S.Em. for pesticides = $\pm$ 0.86 C.D. at 5% = 2.42

S.Em. for rates = $\pm$ 0.52 C.D. at 5% = 1.46

The dosage of 120 g a.i. reduced germination in lindane, chlorpyriphos, phenthoate, phoxim, chlordane and heptachlor treatments, respectively, giving 30.00, 56.0, 61.3, 65.0, 68.7 and 76.7 per cent as compared to 89.0 per cent in control. The same treatments, in addition to isophenphos and malathion + DDT + BHC pesticides significantly prevented germination at 160 g a.i. dosage. All the pesticides showed a remarkable decline in germination than its control due to the application of 200 g a.i. dosage.

It is thus evident from the results that higher concentrations of the pesticides had inhibitory effect on germination. Only aldrin and endosulfan displayed suitability for seed treatment upto 160 g a.i. dosage as the germination obtained was comparable with control.

<u>Barley</u>: The data collated in Table 26 disclosed the harmful effect on germination caused by 80 g a.i. dosage of lindane by preventing 10.0 per cent less germination than control. Phenthoate, chlorpyriphos, phoxim and lindane pesticides depressed germination by 5.3, 10.0, 13.7 and 18.7 per cent, respectively, than the control at 120 g a.i. rate of application. Adverse effect on germination at 160 g a.i. and 200 g a.i. was produced by chlordane, chlorpyriphos, heptachlor, lindane phenthoate and phoxim treatments.

TABLE 26

Mean per cent germination of barley in microplots following seed treatment with emulsifiable concentrates

Sl. No.	Pesticides	APPLICATION RATE g a.i.								Mean of pesticides	
		80		120		160		200			
1.	Aldrin	90.3	(71.89)	91.0	(72.56)	90.4	(71.92)	90.4	(71.92)	90.5	(72.08)
2.	Chlordane	91.0	(72.56)	86.4	(68.32)	80.0	(63.45)	74.0	(59.36)	82.0	(65.92)
3.	Chlorpyriphos	90.3	(71.89)	80.0	(63.44)	65.3	(53.93)	48.0	(43.85)	72.4	(58.28)
4.	Endosulfan	90.3	(71.89)	90.7	(72.24)	91.0	(72.56)	88.4	(70.06)	90.1	(71.69)
5.	Heptachlor	89.5	(71.06)	86.4	(68.32)	79.3	(62.96)	75.3	(60.23)	83.0	(65.64)
6.	Isophenphos	91.0	(72.56)	91.7	(73.27)	90.1	(71.66)	87.7	(69.50)	90.2	(71.75)
7.	Lindane	80.7	(63.92)	71.3	(57.63)	52.0	(46.15)	41.7	(40.20)	62.1	(51.97)
8.	Mal. + DDT + BHC 25:15:10	90.7	(72.24)	90.3	(71.89)	91.0	(72.56)	87.7	(69.50)	90.0	(71.55)
9.	Phenthoate	89.5	(71.06)	84.7	(66.96)	80.0	(63.44)	61.0	(51.36)	79.7	(63.20)
10.	Phoxim	90.3	(71.69)	76.3	(60.90)	67.4	(55.15)	55.4	(48.07)	73.5	(59.00)
11.	Control	90.7	(72.24)	90.0	(71.57)	89.0	(70.64)	90.7	(72.25)	90.1	(71.67)
	Mean of rates	89.6	(71.20)	85.0	(67.92)	80.8	(64.04)	74.5	(59.65)		

S.Em. for interaction = ± 1.52 C.D. at 5% = 4.28

S.Em. for pesticides = ± 0.72 C.D. at 5% = 2.14

S.Em. for rates = ± 0.46 C.D. at 5% = 1.30

In general, seed treatment with all the dosages of aldrin, endosulfan, isophenphos and malathion + DDT + BHC did not wane the germination significantly from the control.

Effect on productive tillering

Powder formulations:

Wheat: The data furnished in Table 27 confessed the unpropitious effect of BHC 10 per cent dust and wettable powders of BHC, carbaryl and landrin with dry application at 2 kg rate, because a reduction of 11.33, 23.67, 10.00 and 15.00 productive tillers was observed in these treatments, respectively, as compared to control. In addition to these pesticides BHC 5 per cent, chlordane and heptachlor dusts also retarded the number of ear-bearing tillers with the administration of 2 kg pesticide with sticker. The application of 4 kg dosage with sticker of BHC 5 and 10 per cent dusts, chlordane and heptachlor dusts and wettable powders of BHC, carbaryl and landrin, and isophenphos + TMTD significantly hindered the productive tillering in comparison to control.

The scanning of these observations disclosed that BHC 10 per cent dust, BHC, carbaryl and landrin wettable powders induced remarkable reductions in productive tillering at all the rates of pesticidal application. Aldrin, endosulfan, larvin, lindane and malathion + DDT + BHC at all the three dosages did not interrupt the earing.

TABLE 27

Mean number of productive tillers (per metre) of wheat in microplots following seed treatment with powder formulations

Sl. No.	Pesticides	APPLICATION RATES AS			Mean of pesticides
		2 kg dry	2 kg with sticker	4 kg with sticker	
1.	Aldrin 5% dust	96.33	96.00	99.33	97.22
2.	BHC 5% dust	91.00	88.00	78.00	85.67
3.	BHC 10% dust	85.67	72.33	48.67	68.89
4.	BHC 50 w.p.	73.33	34.00	5.00	37.44
5.	Carbaryl 50 w.p.	87.00	70.33	61.00	72.78
6.	Chlordane 5% dust	90.00	84.00	72.00	82.00
7.	Endosulfan 4% dust	96.00	99.00	96.00	97.00
8.	Heptachlor 5% dust	91.33	88.00	73.33	84.22
9.	Isophenphos + TMTD 30:10 s.d.	93.00	94.00	83.00	90.00
10.	Landrin 50 w.p.	82.00	70.00	54.00	68.67
11.	Larvin 75 w.p.	96.00	96.00	97.00	96.33
12.	Lindane 0.65% dust	94.33	93.67	92.00	93.33
13.	Mal.+DDT+BHC 3:3:2 dust	97.00	97.00	96.00	96.67
14.	Control	97.00	96.67	99.33	97.67
	Mean of rates	90.71	84.21	75.33	

S.Em. for interaction = ± 2.86 C.D. at 5% = 8.06

S.Em. for pesticides = ± 1.65 C.D. at 5% = 4.65

S.Em. for rates = ± 0.76 C.D. at 5% = 2.14

Barley: An examination of Table 28 indicated that none of the pesticides worked adversely on the production of ear-forming tillers with the use of 2 kg dry dosage of pesticides. The application of 2 kg pesticide with sticker suppressed the earing in comparison to control by 20.67 and 9.67 in wettable powder treatments of BHC and landrin, respectively. With the use of 4 kg pesticide with sticker the number of productive tillers declined in comparison to control by 12.66, 16.66, 20.66, 25.00 and 57.33 in heptachlor, BHC 10 per cent and wettable powders of carbaryl, landrin and BHC, respectively.

The all over data thus pointed out that the application of aldrin, BHC 5 per cent, chlordane, endosulfan, isophenphos + TMTD, larvin, lindane and malathion + DDT + BHC treatments did not cause any deferred effect on ear mumber.

Emulsifiable concentrates:

Wheat: The figures furnished in Table 29 documented reduced number of ear borne tillers than the control by 8.67 in lindane, 11.34 in chlorpyriphos, 12.67 in phenthoate and 9.67 in phoxim with 80 g a.i. dosage. The dosage employed at the rate of 120 g a.i. restrained ear-bearing tillers by 12.00, 12.00, 14.00, 19.00, 23.00 and 38.00, respectively, under chlordane, chlorpyriphos, heptachlor, phenthoate, phoxim and lindane treatments

TABLE 28

Mean number of productive tillers (per metre) of barley in microplots following seed treatment with powder formulations

Sl. No.	Pesticides	APPLICATION RATES AS			Mean of pesticides
		2 kg dry	2 kg with sticker	4 kg with sticker	
1.	Aldrin 5% dust	126.67	122.00	120.67	123.11
2.	BHC 5% dust	123.00	118.00	119.00	120.00
3.	BHC 10% dust	118.33	115.33	102.67	112.11
4.	BHC 50 w.p.	115.00	102.33	62.00	93.11
5.	Carbaryl 50 w.p.	116.00	116.67	98.67	110.44
6.	Chlordane 5% dust	120.33	117.00	111.67	116.33
7.	Endosulfan 4% dust	121.00	123.00	115.33	119.78
8.	Heptachlor 5% dust	115.00	114.67	106.67	112.11
9.	Isophenphos + TMTD 30:10 s.d.	115.33	121.00	118.00	118.11
10.	Landrin 50 w.p.	115.00	113.33	94.33	107.55
11.	Larvin 75 w.p.	118.67	120.00	115.00	117.89
12.	Lindane 0.65% dust	119.00	122.00	118.67	119.89
13.	Mal.+DDT+BHC 3:3:2 dust	116.67	121.33	119.67	119.22
14.	Control	120.00	123.00	119.33	120.78
	Mean of rates	118.57	117.83	108.69	

S.Em. for interaction = ± 3.20 C.D. at 5% = 9.00

S.Em. for pesticides = ± 1.85 C.D. at 5% = 5.20

S.Em. for rates = ± 0.85 C.D. at 5% = 2.41

TABLE 29

Mean number of productive tillers (per metre) of wheat in microplots following seed treatment with emulsifiable concentrates

Sl. No.	Pesticides	APPLICATION RATES IN g a.i 80	120	160	200	Mean of pesticides
1.	Aldrin	114.00	102.33	105.33	100.00	105.41
2.	Chlordane	105.00	96.00	81.00	73.33	88.83
3.	Chlorpyriphos	94.33	95.00	75.00	60.00	81.08
4.	Endosulfan	99.67	100.00	97.00	94.00	97.67
5.	Heptachlor	103.00	94.00	84.00	73.00	88.50
6.	Isophenphos	102.00	104.00	90.00	88.00	96.00
7.	Lindane	97.00	70.00	43.67	10.00	55.17
8.	Mal.+DDT+BHC 25:15:10	108.00	105.00	93.00	96.00	100.50
9.	Phenthoate	93.00	89.00	85.00	82.00	87.25
10.	Phoxin	96.00	85.00	78.00	69.00	82.00
11.	Control	105.67	108.00	102.00	106.00	105.42
	Mean of rates	101.61	95.30	84.91	77.39	

S.Em. for interaction = ± 2.88 C.D. at 5% = 8.10

S.Em. for pesticides = ± 1.44 C.D. at 5% = 4.05

S.Em. for rates = ± 0.87 C.D. at 5% = 2.44

from the control. With the application of 160 g a.i. dosage, malathion + DDT + BHC, isophenphos, phenthoate, heptachlor, chlordane, phoxim, chlorpyriphos and lindane treatments prevented 9.00, 12.00, 17.00, 18.00, 21.00, 24.00, 27.00, and 58.33 productive tillers, respectively, than the control. In addition to these treatments, endosulfan also reduced earing at the highest applied dosage.

A complete view of these observations depicted that seed treatment with chlorpyriphos, lindane, phenthoate and phoxim at all the four tested rates debarred the normal productive tillering. Over and above, the treatments of aldrin acted favourably in allowing as much tillering as in control at the highest dosage and by endosulfan treatment upto 160 g a.i. dosage.

Barley: The application of 80 g a.i. of any of the pesticides was not deterring to the normal production of ear-forming tillers (Table 30). Only lindane and phoxim when applied at the rate of 120 g a.i. yielded 14.67 and 12.00 ears, respectively, lesser than control, while the rest of the pesticides did not reflect significant difference in number of tillers as they remained at par with control. The dosage of 160 and 200 g a.i., respectively, induced only a non-significant numerical decline of productive tillers, being 98.33 and 85.33 in

TABLE 30

Mean number of productive tillers (per metre) of barley in microplots following seed treatment with emulsifiable concentrates

Sl. No.	Pesticides	APPLICATION RATES IN g a.i.				Mean of pesticides
		80	120	160	200	
1.	Aldrin	130.67	132.33	125.67	126.67	128.84
2.	Chlordane	122.00	119.33	98.33	85.33	106.25
3.	Chlorpyriphos	120.67	118.33	106.00	98.33	110.83
4.	Endosulfan	127.00	128.00	122.00	119.00	124.00
5.	Heptachlor	120.00	122.00	104.00	91.00	109.25
6.	Isophenphos	126.00	127.33	113.00	118.00	121.08
7.	Lindane	128.00	112.33	76.33	61.67	94.58
8.	Mal.+DDT+BHC 25:15:10	132.00	124.00	124.67	115.00	123.92
9.	Phenthoate	122.00	123.00	105.00	109.33	114.83
10.	Phoxim	126.00	116.00	108.33	105.00	113.83
11.	Control	129.33	128.00	123.33	125.00	126.42
	Mean of rates	125.79	122.78	109.70	104.94	

S.Em. for interaction = ± 3.82 C.D. at 5% = 10.77

S.Em. for pesticides = ± 1.91 C.D. at 5% = 5.38

S.Em. for rates = ± 1.15 C.D. at 5% = 3.25

chlordane, 106.00 and 98.33 in chlorpyriphos, 104.00 and 91.00 in heptachlor, 76.33 and 61.67 in lindane, 105.00 and 109.33 in phenthoate and 108.33 and 105.00 in phoxim treatments whereas the control had 123.33 and 125.00.

These observations thus denoted that at the lower two dosages all the pesticides stood at par with control except lindane and phoxim at 120 g a.i. dosage in producing normal tillering. Moreover, aldrin, endosulfan, isophenphos, and malathion + DDT + BHC treatments even at the two higher dosages made no deteriorating effect on productive tillering.

Field trials (chemical control of termites)

Seed treatment trials (1978-80 season)

Powder formulations:

Wheat: The perusal of data mentioned in Table 31 revealed adverse effect on germination in comparison to control by BHC 5 per cent @ 2 kg with sticker, BHC 10 per cent @ 2 kg dry, chlordane @ 2 kg dry, heptachlor @ 2 kg with sticker, isophenphos + TMTD @ 2 kg with sticker and larvin @ 4 kg with sticker treatment. The observations pertaining to per cent plant damage indicated that BHC 5 per cent @ 2 kg dry, lindane @ 2 kg dry, 2 and 4 kg with sticker and malathion + DDT + BHC @ 2 kg dry were not effective in checking termite damage. The best

TABLE 31

Effect of seed treatment of wheat with pesticidal powders on germination, termite damage and yield (1979-80)

Sl. No.	Treatments and dosages per qt seed	Mean germi-nation per metre	Mean per cent plant damage		Mean per cent tiller damage (including ear-heads)		Mean grain yield qt/ha
(1)	(2)	(3)	(4)		(5)		(6)
1.	Aldrin 5% dust @ 1.25 kg dry	51.18	3.10	(10.12)	2.60	(9.28)	27.06
2.	Aldrin 5% dust @ 1.25 kg with sticker	52.29	1.20	(6.30)	0.84	(5.27)	30.07
3.	Aldrin 5% dust @ 2 kg dry	50.57	2.70	(9.50)	2.50	(9.10)	27.18
4.	Aldrin 5% dust @ 2 kg with sticker	45.43	1.10	(6.00)	0.56	(4.29)	31.72
5.	Aldrin 5% dust @ 4 kg with sticker	46.34	0.95	(5.59)	0.37	(3.50)	31.08
6.	BHC 5% dust @ 2 kg dry	45.48	7.80	(16.25)	5.50	(13.52)	23.03
7.	BHC 5% dust @ 2 kg with sticker	40.47	5.10	(13.05)	3.00	(10.05)	25.86
8.	BHC 10% dust @ 2 kg dry	38.00	5.40	(13.42)	4.20	(11.85)	25.65
9.	Chlordane 5% dust @ 2 kg dry	40.29	6.10	(14.32)	4.00	(11.52)	25.91
10.	Endosulfan 4% dust @ 2 kg dry	46.38	6.70	(15.03)	4.40	(12.12)	23.14
11.	Endosulfan 4% dust @ 2 kg with sticker	44.33	4.30	(12.00)	2.40	(8.93)	26.28
12.	Endosulfan 4% dust @ 4 kg with sticker	44.67	3.20	(10.32)	3.20	(10.30)	26.86
13.	Heptachlor 5% dust @ 2 kg dry	43.82	2.90	(9.82)	2.60	(9.36)	26.30
14.	Heptachlor 5% dust @ 2 kg with sticker	40.57	1.20	(6.30)	1.30	(6.60)	26.24
15.	Isophenphos + TMTD 30:10 s.d. @ 2 kg dry	44.43	6.30	(14.55)	3.80	(11.22)	25.63

contd....

Table 31 contd...

(1)	(2)	(3)	(4)	(5)	(6)
16.	Isophenphos + TMTD 30:10 s.d. @ 2 kg with sticker	41.20	5.10 (13.06)	3.90 (10.43)	26.61
17.	Larvin 75 w.p. @ 2 kg dry	44.38	3.20 (10.35)	2.90 (9.85)	27.21
18.	Larvin 75 w.p. @ 2 kg with sticker	45.25	1.30 (6.60)	1.10 (6.00)	30.51
19.	Larvin 75 w.p. @ 4 kg with sticker	41.12	1.10 (6.02)	1.20 (6.32)	28.20
20.	Lindane 0.65% dust @ 2 kg dry	48.24	8.80 (17.30)	6.70 (14.95)	24.42
21.	Lindane 0.65% dust @ 2 kg with sticker	46.67	8.10 (16.52)	5.90 (14.10)	24.84
22.	Lindane 0.65% dust @ 4 kg with sticker	45.52	7.80 (16.25)	5.40 (13.45)	25.97
23.	Mal. + DDT + BHC 3:3:2 dust @ 2 kg dry	44.43	7.90 (16.30)	6.30 (14.53)	24.63
24.	Mal.+ DDT + BHC 3:3:2 dust @ 2 kg with sticker	45.33	5.60 (13.71)	5.10 (13.08)	27.47
25.	Mal. + DDT + BHC 3:3:2 dust @ 4 kg with sticker	43.83	4.50 (12.28)	3.30 (10.44)	27.10
26.	Sticker alone	48.81	10.90 (19.30)	8.00 (16.39)	22.93
27.	Control	50.19	10.30 (18.75)	7.50 (15.92)	22.66
	S.Em ±	2.28	1.20	1.30	0.96
	C.D. at 5%	6.47	3.44	3.70	2.73

treatments were aldrin @ 1.25, 2 and 4 kg with sticker, heptachlor @ 2 kg with sticker and larvin @ 2 and 4 kg with sticker, showing 1.20, 1.10, 0.95, 1.20, 1.30 and 1.10 per cent damage as compared to 10.30 per cent in control. Similar trend was observed with regard to tiller damage, as 0.37, 0.56, 0.84, 1.30, 1.10 and 1.20 per cent damage was noted in aldrin @ 4, 2 and 1.25 kg with sticker, heptachlor @ 2 kg with sticker and larvin @ 2 and 4 kg with sticker treatments, respectively.

As regards the grain yield, BHC 5 per cent @ 2 kg dry, endosulfan @ 2 kg dry, lindane @ 2 kg dry and with sticker and malathion + DDT + BHC @ 2 kg dry treatments were not found superior to control. A group of treatments with significantly higher yields comprised of aldrin @ 1.25, 2 and 4 kg with sticker and larvin @ 2 kg with sticker treatments without any difference among them.

It was also seen that seed treatment of wheat with sticker alone had no inhibiting effect on germination, damage and yield.

A complete view of the data in the background of various parameters indicated the suitability of wheat seed treatment with aldrin at all the tested rates with sticker and also of larvin @ 2 kg with sticker. The results further elucidated the utility of sticker as evidenced by a significant lesser damage and higher yield in aldrin @ 1.25 and 2 kg dosages when used with sticker as compared to their dry application.

Barley: An examination of Table 32 documented that germination was retarded with the use of BHC wettable powder @ 2 kg dry, carbaryl @ 2 and 4 kg with sticker and landrin @ 2 kg dry treatments in comparison to control. The per cent plant damage in lindane and malathion + DDT + BHC @ 2 kg dry treatments was as poor as in control. Lowest plant infestation (0.31 per cent) was found in aldrin @ 4 kg with sticker treatment. Other treatments which formed the same group of significance with it were aldrin @ 2 kg with sticker, heptachlor @ 2 and 4 kg with sticker, indicating 0.80, 1.20 and 1.00 per cent damage, respectively. However, larvin @ 2 and 4 kg with sticker treatments, though superior over the control were found inferior to aldrin @ 4 kg with sticker treatment and was similar to aldrin @ 2 kg with sticker treatment. Looking to the observations of per cent tiller damage it appeared that the infestation in BHC 5 per cent @ 2 kg dry, BHC 10 per cent @ 2 kg dry, lindane @ 2 kg dry, 2 and 4 kg with sticker, malathion + DDT + BHC @ 2 kg dry and with sticker treatments was as high as in control. The best results were revealed by aldrin @ 2 and 4 kg with sticker, heptachlor 2 and 4 kg with sticker and larvin @ 2 and 4 kg with sticker and formed one group of significance.

TABLE 32

Effect of seed treatment of barley with pesticidal powders on germination, termite damage and yield (1979-80)

Sl. No.	Treatments and dosages per qt seed	Mean germination per metre	Mean per cent plant damage	Mean per cent tiller damage (including ear-heads)	Mean grain yield qt/ha
(1)	(2)	(3)	(4)	(5)	(6)
1.	Aldrin 5% dust @ 2 kg dry	53.71	2.60 (9.33)	2.20 (8.57)	27.83
2.	Aldrin 5% dust @ 2 kg with sticker	52.05	0.80 (5.14)	0.78 (5.05)	30.48
3.	Aldrin 5% dust @ 4 kg with sticker	54.43	0.31 (3.18)	0.26 (2.92)	30.15
4.	BHC 5% dust @ 2 kg dry	54.10	7.10 (15.45)	5.40 (13.46)	23.17
5.	BHC 5% dust @ 2 kg with sticker	49.91	4.70 (12.51)	2.90 (9.87)	25.75
6.	BHC 5% dust @ 4 kg with sticker	49.33	3.60 (10.87)	2.10 (8.30)	26.60
7.	BHC 10% dust @ 2 kg dry	51.76	4.90 (12.82)	4.70 (12.46)	23.81
8.	BHC 10% dust @ 2 kg with sticker	49.86	2.70 (9.38)	2.50 (9.02)	26.63
9.	BHC 10% dust @ 4 kg with sticker	48.43	3.00 (9.96)	2.40 (8.86)	27.04
10.	BHC 50 w.p. @ 2 kg dry	44.09	4.00 (11.58)	2.60 (9.33)	22.81
11.	Carbaryl 50 w.p. @ 2 kg dry	47.91	4.30 (12.01)	3.70 (11.11)	26.32
12.	Carbaryl 50 w.p. @ 2 kg with sticker	45.13	3.40 (10.64)	2.90 (9.72)	25.35
13.	Carbaryl 50 w.p. @ 4 kg with sticker	44.12	2.40 (8.94)	1.50 (7.01)	23.56
14.	Chlordane 5% dust @ 2 kg dry	50.43	5.10 (13.04)	4.60 (12.45)	25.18
15.	Chlordane 5% dust @ 2 kg with sticker	48.86	2.80 (9.61)	2.30 (8.69)	27.90
16.	Chlordane 5% dust @ 4 kg with sticker	47.52	2.20 (8.56)	1.90 (7.92)	27.22
17.	Endosulfan 4% dust @ 2 kg dry	50.33	6.10 (14.25)	4.30 (11.92)	22.58
18.	Endosulfan 4% dust @ 2 kg with sticker	51.24	3.00 (9.93)	2.70 (9.50)	25.38

contd...

Table 32 contd...

(1)	(2)	(3)	(4)		(5)		(6)
19.	Endosulfan 4% dust @ 4 kg with sticker	47.67	3.80	(11.29)	1.70	(7.42)	27.83
20.	Heptachlor 5% dust @ 2 kg dry	50.19	2.50	(9.12)	2.70	(9.50)	27.17
21.	Heptachlor 5% dust @ 2 kg with sticker	48.52	1.20	(6.25)	1.10	(6.06)	29.91
22.	Heptachlor 5% dust @ 4 kg with sticker	49.57	1.00	(5.70)	0.25	(2.86)	30.21
23.	Isophenphos + TMTD 30:10 s.d. @ 2 kg dry	51.38	6.60	(14.83)	3.10	(10.13)	24.52
24.	Isophenphos + TMTD 30:10 s.d. @ 2 kg with sticker	48.83	4.50	(12.21)	3.70	(11.07)	25.35
25.	Isophenphos + TMTD 30:10 s.d. @ 4 kg with sticker	47.62	5.10	(13.01)	3.10	(10.17)	26.36
26.	Landrin 50 w.p. @ 2 kg dry	43.05	3.50	(10.77)	2.50	(9.07)	22.60
27.	Larvin 75 w.p. @ 2 kg dry	49.95	3.40	(10.57)	2.80	(9.54)	27.02
28.	Larvin 75 w.p. @ 2 kg with sticker	48.62	1.80	(7.69)	1.10	(6.02)	29.90
29.	Larvin 75 w.p. @ 4 kg with sticker	46.51	1.90	(7.89)	0.85	(5.28)	28.42
30.	Lindane 0.65% dust @ 2 kg dry	53.91	7.70	(15.10)	6.40	(14.67)	22.58
31.	Lindane 0.65% dust @ 2 kg with sticker	52.43	5.60	(13.67)	5.50	(13.56)	23.65
32.	Lindane 0.65% dust @ 4 kg with sticker	53.67	5.00	(12.96)	4.90	(12.79)	23.92
33.	Mal. + DDT + BHC 3:3:2 dust @ 2 kg dry	54.86	7.10	(15.40)	5.40	(13.47)	23.06
34.	Mal. + DDT + BHC 3:3:2 dust @ 2 kg with sticker	51.09	4.40	(12.06)	4.50	(12.23)	23.87
35.	Mal. + DDT + BHC 3:3:2 dust @ 4 kg with sticker	52.86	3.80	(11.20)	4.30	(11.93)	24.31
36.	Sticker alone	50.19	9.40	(17.85)	7.80	(16.20)	21.80
37.	Control	51.43	10.00	(18.44)	7.00	(15.32)	22.73
	S.Em ±	1.75		1.12		1.20	0.90
	C.D. at 5%	4.94		3.16		3.36	2.54

The data on grain yield demonstrated the highest yield of 30.46 quintals per hectare in aldrin @ 2 kg with sticker treatment but it was not significantly different from 30.15, 29.91, 30.21, 29.90 and 28.42 quintals per hectare obtained in aldrin @ 4 kg with sticker, heptachlor 2 and 4 kg with sticker and larvin @ 2 and 4 kg with sticker treatments, respectively.

It was further observed that the use of sticker alone did not cause any pronounced effect on plant and tiller damage or yield.

A composite picture of the data keeping in view the various criteria appeared that aldrin, heptachlor and larvin pesticides applied @ 2 and 4 kg with sticker were appropriate for use as seed treatment in barley against termites. However, no significant differences were observed between these two dosages of these three pesticides.

Emulsifiable concentrates:

<u>Wheat</u>: The observations revealed poor germination by chlordane @ 80 g a.i., endosulfan @ 200 g a.i. and heptachlor @ 80 g a.i. treatments as compared with control (Table 33). The data on damage percentage of plants documented that all the treatments except isophenphos @ 80 g a.i. were superior to control. Aldrin treatment at the application rates of 120, 160 and 200 g a.i. and

TABLE 33

Effect of seed treatment of wheat with emulsifiable concentrates on germination, termite damage and yield (1979-80)

Sl. No.	Treatments	Dosages in g a.i./qt seed	Mean germination per metre	Mean per cent plant damage		Mean per cent tiller damage (including ear-heads)		Mean grain yield qt/ha
1.	Aldrin	80	49.33	2.90	(9.82)	2.40	(8.90)	27.86
2.	Aldrin	120	48.00	1.00	(5.70)	0.74	(4.92)	30.68
3.	Aldrin	160	45.19	0.86	(5.33)	0.63	(4.56)	30.12
4.	Aldrin	200	43.67	0.67	(4.70)	0.77	(5.05)	30.36
5.	Chlordane	80	40.53	5.70	(13.83)	3.40	(10.65)	25.32
6.	Endosulfan	80	45.38	4.20	(11.86)	3.70	(11.12)	25.08
7.	Endosulfan	120	44.29	3.10	(10.20)	2.80	(9.65)	28.70
8.	Endosulfan	160	42.52	1.10	(6.05)	0.92	(5.48)	29.43
9.	Endosulfan	200	39.43	0.92	(5.50)	0.64	(4.57)	26.91
10.	Heptachlor	80	41.67	3.10	(10.15)	2.90	(9.82)	25.03
11.	Isophenphos	80	45.24	7.50	(15.87)	6.00	(14.21)	22.54
12.	Isophenphos	120	43.33	5.30	(13.30)	4.80	(12.70)	22.88
13.	Mal. + DDT + BHC 25:15:10	80	46.81	5.60	(13.72)	4.60	(12.37)	24.33
14.	Mal. + DDT + BHC 25:15:10	120	42.52	3.80	(11.24)	4.70	(12.55)	23.97
15.	Control		48.24	10.90	(19.30)	7.20	(15.53)	20.58
	S.Em ±		2.02		1.38		1.26	1.62
	C.D. at 5%		5.85		4.00		3.65	4.69

endosulfan @ 160 and 200 g a.i. identified themselves into one group of significance for their effectiveness and gave 1.00, 0.86, 0.67, 1.10 and 0.92 per cent plant damage, respectively, as compared to 10.90 per cent in control. As regards the per cent tiller damage, all the treatments except isophenphos and malathion + DDT + BHC @ 80 and 120 g a.i. resulted in a significant reduction. An adequate control was achieved with the use of aldrin @ 120, 160 and 200 g a.i. and endosulfan @ 160 and 200 g a.i. where the damage percentages were 0.74, 0.63, 0.77, 0.92, and 0.64, respectively, although no significant differences were observed among them.

No marked differences in grain yield were found in treatments with endosulfan @ 80 g a.i., heptachlor @ 80 g a.i., isophenphos and malathion + DDT + BHC @ 80 and 120 g a.i. as compared to control. The rest of the treatments gave higher yield over the control. The highest yield was obtained in aldrin @ 120 g a.i., followed by aldrin @ 200 and 160 g a.i., endosulfan @ 160 and 120 g a.i., the yield in the treatments being 30.68, 30.36, 30.12, 29.43 and 28.70 quintals per hectare, respectively. However, no significant differences were observed among these treatments.

Taking into account the different parameters it is evident that aldrin @ 120, 160 and 200 g a.i. and endosulfan @ 160 g a.i. were enough competent for use in seed treatment of wheat.

Barley: The data in Table 34 endorsed that the germination was significantly inferior than the control due to treatment with chlordane @ 160 g a.i., chlor-pyriphos @ 120 g a.i., lindane @ 80 g a.i. and phenthoate @ 120 and 160 g a.i. Isophenphos @ 80 g a.i. treatment with respect to per cent plant damage behaved as poor as control. The lowest plant damage (0.86 per cent) was observed in aldrin @ 200 g a.i. treatment and the other treatments at par with it were aldrin @ 160 and 120 g a.i., endosulfan @ 200 and 160 g a.i. and heptachlor @ 120 g a.i. depicting 1.00, 1.20, 1.10, 1.30 and 1.30 per cent damage, respectively. The observations pertaining to per cent tiller damage revealed non-significant reduction in treatments with isophenphos @ 80 g a.i., malathion + DDT + BHC @ 80 a.i., phenthoate at all the tested dosages and phoxim @ 80 g a.i. as compared to control. Significantly lower tiller damage was seen in aldrin @ 120, 160 and 200 g a.i., chlordane @ 160 g a.i., endosulfan @ 160 and 200 g a.i. and heptachlor @ 120 g a.i. treatments. However, all these treatments among themselves were similar in effectiveness.

The grain yield was poor being comparable to control in treatments with chlordane @ 80 g a.i., chlorpyriphos @ 120 g a.i., endosulfan @ 80 g a.i., isophenphos @ 80

TABLE 34

Effect of seed treatment of barley with emulsifiable concentrates on germination, termite damage and yield (1979-80)

Sl. No.	Treatments	Dosages in g a.i./qt seed	Mean germination per metre	Mean per cent plant damage		Mean per cent tiller damage (including ear-heads)		Mean grain Yield qt/ha
(1)	(2)	(3)	(4)	(5)		(6)		(7)
1.	Aldrin	80	54.05	2.70	(9.54)	2.60	(9.28)	26.84
2.	Aldrin	120	55.38	1.20	(6.28)	0.90	(5.45)	30.22
3.	Aldrin	160	51.43	1.00	(5.75)	0.51	(4.07)	31.10
4.	Aldrin	200	52.10	0.86	(5.32)	0.35	(3.40)	30.78
5.	Chlordane	80	50.43	6.10	(14.32)	3.20	(10.28)	23.85
6.	Chlordane	120	47.57	2.30	(8.73)	2.40	(8.98)	27.36
7.	Chlordane	160	43.57	2.20	(8.55)	0.86	(5.32)	26.14
8.	Chlorpyriphos	80	46.66	2.80	(9.70)	4.20	(11.85)	24.73
9.	Chlorpyriphos	120	39.19	3.00	(10.05)	3.60	(10.96)	23.25
10.	Endosulfan	80	52.24	4.60	(12.44)	4.20	(11.78)	23.03
11.	Endosulfan	120	51.29	3.50	(10.75)	3.10	(10.14)	26.57
12.	Endosulfan	160	50.43	1.30	(6.57)	1.10	(6.13)	30.49
13.	Endosulfan	200	47.62	1.10	(6.03)	0.87	(5.36)	29.33
14.	Heptachlor	80	52.24	3.80	(11.30)	2.10	(8.37)	26.65
15.	Heptachlor	120	51.29	1.30	(6.52)	1.00	(5.75)	30.40
16.	Isophenphos	80	54.38	8.40	(16.90)	6.10	(14.31)	21.18
17.	Isophenphos	120	53.62	6.30	(14.58)	4.40	(12.14)	23.81
18.	Isophenphos	160	49.62	6.70	(15.05)	3.10	(10.11)	25.39

contd....

Table 34 contd...

(1)	(2)	(3)	(4)	(5)		(6)		(7)
19.	Isophenphos	200	47.24	4.70	(12.50)	3.30	(10.45)	24.66
20.	Lindane	80	40.38	4.00	(11.60)	3.10	(10.15)	21.60
21.	Mal. + DDT + BHC 25:15:10	80	52.29	6.80	(15.14)	4.90	(12.74)	23.09
22.	Mal. + DDT + BHC 25:15:10	120	51.28	4.50	(12.25)	3.80	(11.31)	24.53
23.	Mal. + DDT + BHC 25:15:10	160	48.48	3.40	(10.64)	3.30	(10.45)	24.19
24.	Mal. + DDT + BHC 25:15:10	200	47.29	2.70	(9.45)	3. 20	(10.22)	25.89
25.	Phenthoate	80	49.68	7.00	(15.33)	5.80	(13.95)	20.39
26.	Phenthoate	120	42.62	6.40	(14.62)	5.10	(13.10)	20.65
27.	Phenthoate	160	39.43	6.50	(14.78)	4.90	(12.73)	20.24
28.	Phoxim	80	50.43	7.10	(15.50)	4.80	(12.68)	21.64
29.	Control		52.62	11.30	(19.66)	7.80	(16.19)	20.92
	S.Em. ±		2.09		1.06		1.26	1.30
	C.D. at 5%		5.93		3.01		3.56	3.70

and 120 g a.i., lindane @ 80 g a.i., malathion + DDT + BHC @ 80, 120, 160 g a.i., and phenthoate @ 80, 120, 160 g a.i. and phoxim @ 80 g a.i. The yield was highest in aldrin @ 160 g a.i. followed by aldrin @ 200 g a.i., endosulfan @ 160 g a.i., heptachlor @ 120 g a.i., aldrin @ 120 g a.i. and endosulfan @ 200 g a.i. which gave 31.10, 30.78, 30.49, 30.40, 30.22 and 29.33 quintals per hectare. But there was no marked difference among these treatments.

An examination of the over-all table revealed that aldrin @ 120, 160 and 200 g a.i., endosulfan @ 160 and 200 g a.i. and heptachlor @ 120 g a.i. treatments were befitting for barley seed treatment since adequate control of termites was accomplished besides, higher grain yield.

Seed treatment trials (1980-81 season)

Powder and emulsifiable formulations:

<u>Wheat</u>: The data given in Table 25 disclosed no significant variation in germination among all the treatments. The data of per cent plant damage depicted that carboxin alone and both the formulations of BPMC did not provide relief from termite infestation over the control. Minimum plant damage (0.88 per cent) was noticed in aldrin @ 120 g a.i. with carboxin treatment. The other equally effective treatments were aldrin @ 1.25 and 2 kg dust with sticker, aldrin @ 120 g a.i., endosulfan @ 160 g

TABLE 35

Effect of seed treatment of wheat with emulsifiable and powder formulations on germination, termite damage and yield (1980-81)

Sl. No.	Treatments and dosages per qt seed	Mean germination per metre	Mean per cent plant damage	Mean per cent tiller damage (including ear-heads)	Mean number of damaged ear-heads per hectare	Net grain loss due to ear-head damage kg/ha	Mean grain yield qt/ha
1.	Aldrin 5% dust @ 1.25 kg with sticker	41.73	2.30 (8.74)	1.10 (6.05)	22470 (149.90)	20.67	30.12
2.	Aldrin 5% dust @ 2 kg with sticker	40.80	1.40 (6.85)	0.87 (5.35)	17964 (134.03)	16.33	31.17
3.	BPMC 4% dust @ 2 kg with sticker	45.91	7.80 (16.25)	6.40 (14.61)	124651 (353.06)	114.68	23.12
4.	Larvin 75 w.p. @ 2 kg with sticker	40.00	2.50 (9.12)	1.20 (6.30)	24986 (158.07)	21.98	29.53
5.	Aldrin @ 120 g a.i.	44.79	0.91 (5.46)	0.25 (2.20)	4967 (70.48)	4.37	32.06
6.	Aldrin @ 120 g a.i. + Carboxin @ 150 g a.i.	42.07	0.83 (5.38)	0.28 (3.04)	4492 (67.02)	4.03	31.69
7.	BPMC @ 120 g a.i.	44.31	6.90 (15.24)	6.10 (14.25)	120390 (346.97)	108.76	23.25
8.	Endosulfan @ 160 g a.i.	40.27	1.80 (7.70)	0.97 (5.67)	20466 (143.06)	17.83	29.97
9.	Endosulfan @ 160 g a.i. + Carboxin @ 150 g a.i.	41.20	1.70 (7.48)	0.89 (5.42)	18442 (135.80)	16.17	29.29
10.	Carboxin @ 150 g a.i.	42.33	9.80 (18.26)	7.90 (16.32)	151316 (388.99)	138.21	21.03
11.	Control	43.62	10.20 (18.65)	8.30 (16.78)	158916 (398.64)	149.29	20.75
	S.Em. ±	3.63	1.22	1.41	25.84	5.56	1.39
	C.D. at 5%	N.S.	3.60	4.16	76.23	16.40	4.10

a.i. alone and with carboxin as the damage depicted by these treatments was 2.30, 1.40, 0.91, 1.80 and 1.70 per cent, respectively, in comparison to 10.20 per cent in control. The per cent tiller damage in carboxin alone and both the formulations of BPMC did not show any reasonable check of termite infestation. The best results were demonstrated by aldrin @ 120 g a.i., followed by aldrin @ 120 g a.i. with carboxin @ 150 g a.i., aldrin @ 2 kg with sticker, endosulfan @ 160 g a.i. with carboxin 150 g a.i., endosulfan @ 160 g a.i., aldrin @ 1.25 kg with sticker and larvin @ 2 kg with sticker which restricted the damage to 0.25, 0.28, 0.87, 0.89, 0.97, 1.10 and 1.20 per cent, respectively, as compared to 8.30 per cent in control.

The number of damaged ear-heads was high in carboxin alone and in both the treatments of BPMC formulations. The lowest number of damaged ear-heads was observed in aldrin @ 120 g a.i. with carboxin @ 150 g a.i. treatment. The other treatments similar in effectiveness and significantly better than control were aldrin @ 2 kg with sticker, aldrin @ 120 g a.i. and endosulfan @ 160 g a.i. with and without carboxin. But the treatments with aldrin @ 1.25 kg with sticker and larvin @ 2 kg with sticker were inferior to aldrin emulsion treatments with or without carboxin. The figures of net grain loss due to ear-head damage revealed the ineffectiveness of carboxin alone treatment being at par with control. Moreover, in comparison to aldrin @ 120 g a.i. treatment, both the treatments of BPMC formulations, and larvin @ 2 kg with sticker were also inferior, although the latter was significantly superior over BPMC treatments and control.

As regards grain yield, carboxin and both the treatments of BPMC formulations performed poorly as the yields remained at par with control. The rest of the treatments gave better yields than the control, although no significant differences were observed among themselves.

The over-all picture of the data revealed that aldrin @ 120 g a.i. with or without carboxin and endosulfan @ 160 g a.i. with or without carboxin and aldrin @ 1.25 and 2 kg with sticker treatments were better for seed treatment of wheat in view of the least damage and higher yield.

<u>Barley</u>: The observations presented in Table 36 indicated that germination was not affected by any of the treatments. The per cent plant damage did not reduce appreciably in BPMC dust and emulsion treatments as well as in carboxin alone treatment as compared to control. The lowest plant damage (0.81 per cent) was obtained in aldrin @ 120 g a.i. treatment, and other treatments within the same group of significance were aldrin @ 2 kg with sticker, heptachlor @ 2 kg with sticker, aldrin @ 120 g a.i. with carboxin, endosulfan @ 160 g a.i. alone

TABLE 36

Effect of seed treatment of barley with emulsifiable and powder formulations on germination, termite damage and yield (1980-81)

Sl. No.	Treatments and dosages per qt seed	Mean germi-nation per metre	Mean per cent plant damage		Mean per cent tiller damage (including ear-heads)		Mean number of damaged ear-heads per hectare		Net grain loss due to ear-head damage kg/ha	Mean grain yield qt/ha
1.	Aldrin 5% dust @ 2 kg with sticker	55.33	1.30	(6.56)	1.00	(5.78)	26486	(162.74)	28.13	28.93
2.	BPMC 4% dust @ 2 kg with sticker	56.24	8.10	(16.52)	7.40	(15.80)	182374	(427.05)	199.61	22.36
3.	Heptachlor 5% dust @ 2 kg with sticker	54.09	1.60	(7.30)	1.10	(6.12)	28427	(168.60)	30.28	28.17
4.	Larvin 75 w.p. @ 2 kg with sticker	52.76	2.80	(9.64)	1.30	(6.60)	33438	(182.86)	34.78	28.14
5.	Aldrin @ 120 g a.i.	57.91	0.81	(5.16)	0.47	(3.95)	12415	(111.42)	10.16	30.55
6.	Aldrin @ 120 g a.i. + Carboxin @ 150 g a.i.	60.43	0.97	(5.66)	0.39	(3.53)	10464	(102.29)	10.31	31.46
7.	BPMC @ 120 g a.i.	58.27	7.90	(16.31)	6.10	(14.33)	149300	(386.39)	160.23	23.24
8.	Endosulfan @ 160 g a.i.	56.86	1.60	(7.28)	1.00	(5.80)	25920	(161.00)	28.51	28.97
9.	Endosulfan @ 160 g a.i. + Carboxin @ 150 g a.i.	54.24	1.70	(7.52)	0.86	(5.33)	22453	(149.84)	25.70	29.18
10.	Heptachlor @ 120 g a.i.	53.43	0.95	(5.58)	0.71	(4.84)	18387	(135.60)	20.02	30.19
11.	Heptachlor @ 120 g a.i. + Carboxin @ 150 g a.i.	54.67	1.10	(6.05)	0.65	(4.63)	16960	(130.23)	17.65	29.11
12.	Carboxin @ 150 g a.i.	56.76	10.60	(19.03)	8.30	(16.72)	197071	(443.93)	215.77	20.42
13.	Control	55.31	11.20	(19.57)	8.70	(17.16)	205490	(453.31)	226.04	21.33
	S.Em ±	4.96		1.21		1.38		24.03	6.51	1.18
	C.D. at 5%	N.S.		3.53		4.03		70.14	19.00	3.43

and with carboxin and heptachlor @ 120 g a.i. alone and with carboxin as the damage demonstrated by them was 1.30, 1.60, 0.97, 1.60, 1.70, 0.95 and 1.10 per cent, respectively. However, treatment with larvin @ 2 kg with sticker was inferior to some of these treatments but was at par with aldrin @ 2 kg with sticker, heptachlor @ 2 kg with sticker, and endosulfan @ 160 g a.i. alone and with carboxin treatments. The per cent tiller damage was found to be as much as that of control in carboxin and with both the formulations of BPMC treatments. Rest of the treatments were significantly better than control and behaved similarly in checking termite infestation. The number of damaged ear-heads per hectare did not reduce with the use of carboxin and both the formulations of BPMC as the damage stood at par with control. The rest of the treatments barring larvin @ 2 kg with sticker were as good as the best treatment of aldrin @ 120 g a.i. with carboxin. As regards net grain loss due to ear-head damage, carboxin treatment alone gave poor results. Lowest grain loss was found in aldrin @ 120 g a.i. treatment. Additional treatments with identical level of significance were aldrin @ 2 kg with sticker, aldrin @ 120 g a.i. with carboxin, endosulfan @ 160 g a.i. and heptachlor @ 120 g a.i. both with and without carboxin.

The grain yield in BPMC treatments with both the formulations and carboxin treatments was as poor as in control. The remaining treatments without any significant difference gave better yields than control.

A comprehensive retrace of the tabulated data indicated the suitability of seed treatment of barley with emulsions of aldrin, endosulfan and heptachlor alone or with carboxin as well as with powder formulations of aldrin, heptachlor and larvin @ 2 kg with sticker for the control of termites.

Post-sowing treatment with irrigation (1978-79 season):

Wheat: All the treatments were significantly superior than the control which is evident from the data recorded on the number of damaged plants and ear-heads as well as grain yield (Table 37). Two weeks after the treatment, chlorpyriphos at 400, 600 and 800 g a.i. and chlordane at 400 g a.i. per hectare dosages were at par and gave significantly higher damage (4757 to 9557 damaged plants per hectare) than the remaining treatments which gave 2211 to 4581 damaged plants per hectare as against 83666 damaged plants in untreated check. There was no significant difference between 1000 and 400 g a.i. per hectare dosages of aldrin, heptachlor and lindane. The minimum dosages of different insecticides with best results were, 400 g a.i. of aldrin, lindane and heptachlor, 600 g a.i. of chlordane and 1000 g a.i. of chlorpyriphos. Increase in the dosages of these insecticides though demonstrated a decrease in the infestation, the differences

TABLE 37

Effect of application of pesticidal emulsions alongwith irrigation on termite damage and yield of wheat (1978-79)

Sl. No.	Treatments	Dosage g a.i. per ha	Mean number of damaged plants per hectare 2 weeks after treatment		Mean number of damaged ear-heads per hectare		Mean grain yield qt/ha
1.	Aldrin	1000	2211	(47.02)	2737	(52.32)	29.34
2.	Aldrin	800	3175	(56.35)	7262	(85.22)	28.64
3.	Aldrin	600	3958	(62.91)	12071	(109.87)	28.24
4.	Aldrin	400	4438	(66.62)	15366	(123.96)	28.07
5.	Chlordane	1000	3387	(58.20)	10660	(103.25)	28.39
6.	Chlordane	800	4206	(64.85)	16126	(126.91)	27.77
7.	Chlordane	600	4339	(65.87)	18349	(135.46)	27.16
8.	Chlordane	400	4757	(93.58)	83313	(288.64)	22.92
9.	Chlorpyriphos	1000	4581	(67.68)	18233	(135.03)	26.94
10.	Chlorpyriphos	800	8584	(92.65)	97294	(311.92)	22.57
11.	Chlorpyriphos	600	8990	(94.82)	112326	(335.15)	22.26
12.	Chlorpyriphos	400	9557	(97.76)	130552	(361.32)	22.15
13.	Heptachlor	1000	2554	(50.54)	4259	(65.26)	28.82
14.	Heptachlor	800	3405	(58.35)	7117	(84.36)	28.43
15.	Heptachlor	600	4206	(64.85)	16221	(127.36)	27.95
16.	Heptachlor	400	4384	(66.21)	17461	(132.14)	27.37
17.	Lindane	1000	3024	(54.99)	5636	(75.07)	28.79
18.	Lindane	800	4397	(66.31)	12681	(112.61)	28.11
19.	Lindane	600	4206	(64.85)	16126	(126.99)	27.81
20.	Lindane	400	4070	(63.80)	16644	(129.01)	27.58
21.	Control		83666	(289.25)	386610	(621.78)	18.37
	S.Em. ±			7.66		25.06	0.88
	C.D. at 5%			21.88		71.61	2.51

were not significant. Similar trend was observed when the mean grain yields were compared. The ear-head damage gave almost parallel results except that aldrin at 1000 g a.i. dosage was observed to give significantly better control than 400 g a.i. of the same insecticide or 600 g a.i. of lindane or heptachlor or 800 g a.i. of chlordane or 1000 a.i. of chlorpyriphos. But there was no difference between 1000, 800 and 600 g a.i. dosages or between 800, 600 and 400 g a.i. dosages of aldrin.

Thus the minimum effective dosages of different insecticides indicating no significant difference with their higher dosages were choosen for the next season trial barring aldrin at 1000 g a.i. dosage, though slightly better than its lowest tried dosage was deleted in consideration of the low cost-benefit ratio.

Post-sowing treatment with irrigation (1980-81 season):

Wheat: The data of the post-sowing effect of lower dosages of aldrin, chlordane, heptachlor and lindane on termite infestation and yield are shown in Table 38. The observations on plant and ear-head damage and grain yield revealed that even the lowest tried dosages (chlordane 300 g a.i., heptachlor and lindane 150 g a.i. per hectare) were significantly better than control. The observations on plant damage recorded after two weeks of treatment indicated the best control of termites with 400 g a.i.

TABLE 38

Effect of application of pesticidal emulsions alongwith irrigation on termite damage and yield of wheat (1980-81)

Sl. No.	Treatments	Dosage g a.i. per ha	Mean number of damaged plants per hectare 2 weeks after treatment		Mean number of damaged ear-heads per hectare		Mean grain yield qt/ha
1.	Aldrin	400	4120	(64.19)	13635	(116.77)	29.23
2.	Aldrin	300	5595	(74.80)	19505	(139.66)	28.50
3.	Aldrin	150	30318	(174.12)	61034	(247.05)	25.31
4.	Chlordane	600	5768	(75.95)	18545	(136.18)	28.95
5.	Chlordane	400	27549	(165.98)	57379	(239.54)	26.15
6.	Chlordane	300	45084	(212.33)	90914	(301.52)	22.77
7.	Heptachlor	400	6551	(80.94)	17119	(130.84)	28.93
8.	Heptachlor	300	24863	(157.68)	45963	(214.39)	26.02
9.	Heptachlor	150	46238	(215.03)	107407	(327.73)	22.55
10.	Lindane	400	7429	(86.19)	17644	(132.83)	28.05
11.	Lindane	300	23004	(151.67)	55408	(235.39)	26.12
12.	Lindane	150	51765	(227.52)	113481	(336.87)	21.73
13.	Control	-	86978	(294.92)	325242	(570.30)	19.25
	S.Em. ±			7.42		14.05	0.49
	C.D. at 5%			21.65		41.01	1.44

of aldrin and heptachlor, 600 g a.i. of chlordane and 400 g a.i. of lindane. However, lindane was not significantly superior than aldrin at 400 g a.i. dosage. The observations of ear-head damage demonstrated that 400 g a.i. dosage of aldrin, heptachlor and lindane, 600 g a.i. of chlordane and even 300 g a.i. of aldrin were equally effective in preventing the crop from termite attack at the earing stage and also in increasing the grain yield. There was no significant difference between 300 g a.i. of heptachlor and lindane, 400 g a.i. of chlordane and 150 g a.i. of aldrin. But this group of treatments gave significantly less protection to the crop as compared to the first group of insecticides (aldrin, heptachlor and lindane at 400 g a.i. chlordane at 600 g a.i. and aldrin at 300 g a.i. per hectare).

The over-all data indicated that aldrin at 400 and 300 g a.i., heptachlor and lindane at 400 g a.i. and chlordane at 600 g a.i. were quite effective in retarding termite damage alongwith an increase of grain yield.

Mound treatment

Relative efficacy of insecticides:

The data collated in Table 39 indicated that the six insecticidal formulations tested were variably effective in destroying the colonies of the mound-building termite, <u>Odontotermes obesus</u> (Rambur). Drenching of aldrin

TABLE 19

Mean seedling dry weight (mgs) of wheat following seed treatment with powder formulations

Sl. No.	Pesticides	APPLICATION RATES AS			Mean of pesticides
		2 kg dry	2 kg with sticker	4 kg with sticker	
1.	Aldrin 5% dust	28.75	29.08	28.63	28.82
2.	BHC 5% dust	28.68	24.25	21.98	24.97
3.	BHC 10% dust	24.85	20.20	16.50	20.52
4.	BHC 50 w.p.	17.08	12.13	9.28	12.83
5.	Carbaryl 50 w.p.	17.85	12.70	9.17	13.24
6.	Chlordane 5% dust	26.73	25.18	22.00	24.64
7.	Endosulfan 4% dust	28.83	28.45	27.30	28.19
8.	Heptachlor 5% dust	28.98	26.10	21.35	25.48
9.	Isophenphos+TMTD 30:10 s.d.	29.00	27.83	26.65	27.83
10.	Landrin 50 w.p.	17.90	12.00	9.80	13.23
11.	Larvin 75 w.p.	29.10	27.75	27.40	28.08
12.	Lindane 0.65% dust	29.20	28.74	27.58	28.51
13.	Mal.+DDT+BHC 3:3:2 dust	28.88	26.48	25.30	26.89
14.	Control	30.00	28.80	28.95	29.25
	Mean of rates	26.13	23.55	21.56	

S.Em. for interaction = $\pm$ 0.78 C.D. at 5% = 2.16

S.Em. for pesticides = $\pm$ 0.46 C.D. at 5% = 1.27

S.Em. for rates = $\pm$ 0.21 C.D. at 5% = 0.58

TABLE 39

Relative efficacy of insecticides against mound-inhabiting termite, *Odontotermes obesus* (Rambur) during 1978

Sl. No.	Treatment	Formulated dosage per cu.m of mound volume ml/g	Number of mounds treated			Number of mounds exterminated			Per cent mounds exterminated
			Site A	Site B	Site C	Site A	Site B	Site C	
1.	Aldrin 30 e.c. + water	20	4	3	3	4	3	3	100.00
2.	Chlordane 20 e.c. + water	30	4	3	3	4	2	1	70.00
3.	Heptachlor 20 e.c. + water	30	5	3	3	5	3	3	100.00
4.	Lindane 20 e.c. + water	30	4	4	3	3	3	3	81.81
5.	Phorate 10 G	50	3	4	4	2	3	2	63.63
6.	Phorate 10 G + water	50	4	3	3	3	3	3	90.00
7.	Control (water only)	-	3	3	3	-	-	-	-

and heptachlor emulsions was most effective as all the mound colonies were exterminated. The other treatments in the decreasing order of efficacy were, water drenching followed by application of phorate, lindane emulsion, chlordane emulsion and phorate granules without water. Even in the case of least effective treatment i.e. application of phorate granules alone, as such as 63.83 per cent of mound colonies were destroyed.

Effect of mound poisoning on infestation in wheat crop:

The extermination of termite colonies inside the mounds in the vicinity of wheat fields was effective in reducing termite damage in wheat crop. The observations recorded before and after drenching of the mound with aldrin emulsion revealed reduction in termite infestation to the extent of 49.10 to 61.45 per cent in the early crop stage and 51.36 to 70.45 per cent at the earing stage (Table 40).

TABLE 40

Effect of mound destruction on termite infestation in wheat crop during 1978-79 and 1979-80 season at Manoharpur

Location	Station	PER CENT INFESTATION				PER CENT REDUCTION	
		Before treatment (1978-79)		After treatment (1979-80)			
		Early stage	Earing stage	Early stage	Earing stage	Early stage	Earing stage
A	1	5.24	9.52	2.02	4.63	61.45	51.36
	2	6.12	11.10	2.92	3.28	52.29	70.45
B	1	4.63	8.51	2.26	3.99	51.19	53.11
	2	6.15	10.32	3.13	4.86	49.10	52.91

CHAPTER V

D I S C U S S I O N

Adherence of pesticidal powders

Relative adherence of dry powders:

The testes of adherence with dry pesticidal powders to wheat and barley seeds revealed a great variability in the amount of coatings in the present studies. Maximum amount of 1.382 and 1.474 kg of chlordane dust and a minimum quantity of 0.289 and 0.319 kg of landrin wettable powder was retained on wheat and barley seeds, respectively, when the pesticides were applied at the rate of 2 kg dry per 100 kg seed. Other pesticides showed different amounts of adherence. The grouping of wettable powders of different pesticides, dust and wettable formulations of the same pesticide and even the two differing dust percentages of a pesticide did not signify any similitude in the amount of retention. Such variations in the deposition of pesticides as emphasized by Ebeling (1963) are due to the involvement of a number of factors like size, shape, electrostatic charge of the particles, the chemical and physical properties of the diluent, adjuvants etc. and the nature of the adhering surface. While determining the adherence of several pesticides on wheat, Baicu and Diaconu (1972) found that only compounds, PEL-120, PLB and TBZ gave the best adhesiveness. Decker et al. (1950) observed that pesticides like chlordane and toxaphene which leave waxy or sticky deposits adhered better than those that leave crystalline deposits like DDT. Metcalf and Flint (1962) have also mentioned that oily materials help in increasing the deposits. The findings of all these authors adequately conform to the present investigations where a great variability in adherence has been noticed and chlordane showed the maximum deposit on wheat and barley seeds.

It was further observed that barley seed retained comparatively more quantum of powder than wheat seed. Baicu and Diaconu (1972) reported that the adhesiveness on the seed is basically related to its size as smaller seeds retained larger amounts. Although barley seed used in the present studies was slightly bigger in size than wheat seed, still it retained a higher amount of powders. Jeffs and Tuppen (1978) indicated that adhesion of particles is a complicated process involving factors from molecular forces to physical trapping of small particles. Hence, it is conjectured that the rough and pubescent surface of barley seed provided favourable chances for physical trapping of particles leading to more deposits. Relatively lesser deposits on wheat seed inspite of its smaller size would have, therefore, occurred due to its smooth surface.

The application of different powders at the rate of 2 kg dry per 100 kg seed showed the practical adherence ranging from 9.45 to 69.10 per cent for wheat and from 10.95 to 73.70 per cent for barley (Table 3). Lord *et al*. (1971 a,b) also observed that dry powders become separated from the seed as they do not adhere strongly to the seed. The commercially treated seed samples examined by these workers revealed adherence even less than one-tenth of the theoretical dose applied in some cases. It is thus seen that with the dry application of pesticidal powders, a lesser amount retains on the seed than the actual dose of application. Moreover, the type of formulation and the kind of seed are also responsible for the variability in the quantum of pesticidal loading.

Effect of various dosages on adherence:

The investigations of Srivastava (1955) indicated a significant increase in the coating on wheat seed as the concentrations of pesticidal powders were gradually increased from 2 to 32 oz per 100 lb seed. He found that the rate of increase was not uniform for all the treatments. Only slight increase in adherence was observed by him in heptachlor between 16 and 32 oz concentrations whereas 'Seed Guard' gave the highest coating. The present observations also revealed significant increase in the coating of the three pesticides tested here on wheat and barley seeds. For example, on wheat seed the loadings of chlordane 5 per cent dust were 0.838, 1.388 and 1.533 kg per 100 kg seed with the application of 1, 2 and 4 kg dosages, respectively (Table 4). However, the rate of increase did not follow a linear pattern beyond 2 kg rate. It is seen that in wheat the additional loading of chlordane was 0.550 kg with the rise of application rate from 1 to 2 kg, and 0.145 kg with the rise in application rate from 2 to 4 kg. Chlordane 5 per cent dust gave the highest coating on wheat as well as on barley seeds followed in decreasing order by aldrin 5 per cent dust and BHC 10 per cent dust at various dosages. Thus these results in general corroborate with the findings of Srivastava (1955).

Determination of a suitable sticker:

The application of dry powder does not provide a desirable amount of loading on the seed to achieve necessary protection to the germinating seed or plant from the invading pest. Several materials have been mentioned in the literature as stickers to increase adherence. Generally, 2.5 to 3 per cent methyl cellulose is used as a sticker (Reynold, 1958). From an economical view point, aside methyl cellulose, gum arabic and soluable starch were also tested here. The results of the present studies demonstrated that 2 per cent methyl cellulose was the best adhesive in comparison to gum arabic and soluable starch at the same concentration (Table 6). It was also observed that irrespective of the dry adherence ability of a pesticide, the stickers brought about a uniform amount of loading at lower dosage and methyl cellulose even at higher dosage demonstrated the same trend due to its strong force of adhesion. It was also seen that the adherence of powders increased with the rise of application rate. The use of stickers for uniform and better coating has been advocated by Starks and Lilly (1955 b). Similarly, Jeffs (1973) and Jeffs and Walker (1973) obtained more quantity of pesticidal powders on the seed with the use of sticker. Griffiths et al.(1970 a) in their test confirmed that certain adhesives allowed better loading on the seed in comparison to standard siliceous earth formulations. The present data are thus in agreement with the findings of these researchers.

Effect on germination

Usually a compound in soil application may not be so harmful to germination than when used with the seed because the latter method of treatment places the chemical in an intimate contact with the seed. Detrimental effect on germination caused by seed treatment with certain chemicals are well known and the severity of such effects is mainly due to the nature of the chemical. Over and above, the degree of its influence is also dependent upon the applied dosage, the type of formulation, the technique of treatment, the kind and variety of seed, as well as other conditions of experimentation.

The results of the present studies on seed treatment of wheat and barley reveal that several factors are responsible for the extent of influence on germination. They are the specificness of the pesticide, the dosage loaded on the seed, the type of formulation, the kind of seed and the testing conditions.

Specificness of pesticides:

The specific effects of certain compounds on germination by treating wheat and barley seed were observed under green-house and field tests (Tables 7 to 10 and 23 to 26). The dry application of dusts not exceeding 10 per cent, a 40 per cent isophenphos + TMTD s.d. and 75 per cent larvin w.p. did not hamper the germination of wheat in green-house test. However, 50 per cent w.p. of BHC, carbaryl and landrin were found to be injurious to germination of wheat. Obviously one of the possible reasons of the adverse effects on germination by these wettable formulations was their more concentrated form in comparison to most of the other compounds tested alongwith them. On the other hand it was also seen that larvin w.p. which was in a highly concentrated form than the rest of the wettable powders, did not affect adversely on the germination. From the results it appear that the two new compounds, landrin and larvin w.p. of the carbamate group behaved unlike each other in respect of germination. Similarly, another recent combination product, isophenphos + TMTD 40 per cent s.d. loaded on the seed in comparable amounts to 50 per cent w.p. of BHC and carbaryl (Tables 1) did not hamper germination (Tables 7 and 23). It was further observed that aldrin 5 per cent dust was quite suitable when applied at 2 and 4 kg rates with sticker to 100 kg seed of wheat. Whereas, 5 per cent BHC, chlordane and heptachlor dusts with approximately the same amounts of loading on the seed at both these rates inhibited the germination. These findings indicate that pesticides at the same rate of application may behave differently in the degree of their effectiveness mainly due to their specific chemical composition. The treatment of barley seed with wettable powders of BHC, carbaryl and landrin also affected the germination while larvin did not.

The data on seed treatment of wheat with emulsifiable concentrates at the lowest dosage with chlordane, chlorpyriphos, lindane, phenthoate and phoxim pesticides indicated significantly lesser germination than control. At the same rate of application the treatment of aldrin, endosulfan, heptachlor, isophenphos and malathion + DDT + BHC gave as good germination as untreated check. The barley seed treated with emulsifiable concentrates also demonstrated that a few pesticides with a similar dosages were unfavourable to germination while others did not hamper the germination.

The germination recorded in the microplot tests of wheat and barley treated with powder and emulsifiable formulations showed a similar trend of diverse effects of certain compounds.

It is thus quite clear from these results on germination that certain pesticides impaired germination while others either caused no adverse effect or just affected mildly, albeit the dosage was the same. These results have also elucidated an additional information that some recent pesticides i.e. landrin, phenthoate and phoxim retarded the germination of wheat and barley.

Several workers (Fleming, 1948; Primost, 1950; Jameson *et al*., 1951; Cox and Lilly, 1952; Srivastava, 1955; Patel, 1962; Bowling, 1964, 1965; Sahni and Butani, 1966; Sachan *et al*., 1967; Griffiths *et al*., 1969; Verma *et al*., 1979 a,b) have observed the effects of some common and a few new pesticides on germination of cereal crops. Their results can not be compared directly with the present results obtained for these pesticides. It is because of the deviation in the technique of treatments, the pesticides, their formulations and the dosages used as well as the methods of testing adopted by various workers. However, the effect of seed dressing on germination of wheat with dust formulation of aldrin, BHC, chlordane and lindane with similar dosages was compared by Bindra (1960). He found that except aldrin, all the other compounds gave relatively poor germination indicating the specificness of these chemicals. The influence of the nature of BHC is further evident from the data of Verma et al. (1971). They found that wettable powder of BHC used as dry or wet was injurious to germination of wheat. In a subsequent study Verma (1974) observed that aldrin dust did not inhibit wheat germination while BHC dust adversely affected the germination when the seed was treated with equal amounts of the pesticides. Allen (1971) treated wheat seed with identical dosages of phosalone and endosulfan and found that the former treatment reduced the germination while the latter caused no inhibition.

In this way, broadly speaking the present findings extent support to prior observations of other workers with regard to specific effects of pesticides on germination when used as seed dressers.

Effect of dosages:

Besides, the specificness of the compound for its effect on germination, the degree of inhibition is also influenced by the amount of the pesticide retained on the seed. The results dealt in these studies have displayed the trend of declining germination on account of the increasing rate of application with most of the compounds.

The treatment of wheat seed with dry wettable powders of BHC, carbaryl and landrin at the rate of 2 kg per 100 kg seed demonstrated adverse effects on germination in comparison to other compounds in green-house tests (Table 7). The germination further declined due to increased loading when these pesticides were applied at 2 and 4 kg rates with sticker. For example, BHC wettable powder treatment @ 2 kg dry gave 76.1 per cent germination and the application of 2 and 4 kg with sticker allowed 46.0 and 10.8 per cent germination, respectively. The dry application of BHC 5 and 10 per cent dusts @ 2 kg was not harmful to germination but these compounds manifested reduction with the increase in pesticidal loadings. The application rate of 2 and 4 kg dust with sticker retarded germination from 90.5 to 78.2 per cent in BHC 5 per cent and from 84.4 to 45.0 per cent in BHC 10 per cent dust, respectively. Even certain pesticides like aldrin, endosulfan and larvin powders which did not cause a significant reduction in germination with increased coating indicated a non-significant numerical decrease. The germination of barley seed treated with powders also evidenced the increasing inhibition in germination with the rise of adherence in green-house test (Table 8). For instance, BHC w.p. showed 99.7, 94.2 and 84.4 per cent and landrin w.p. gave 100.0, 91.0 and 83.1 per cent germination, respectively, at the rate of 2 kg dry, and 2 and 4 kg with sticker. The microplot trials of wheat and barley seed treated with powder formulations exhibited the same tendency of decreasing germination with increasing amount of pesticidal coating on the seed (Tables 23 and 24).

Treatment of wheat and barley seeds with emulsifiable concentrates have shown that the germination declined gradually with the increasing rate of application in green-house as well as in microplot tests. The effect on germination with emulsifiable formulations of chlorpyriphos, lindane, phenthoate and phoxin treatments was more severe than other compounds like aldrin, endosulfan, isophenphos and malathion + DDT + BHC.

Wheat and barley seeds treated with powder and emulsifiable formulations and tested under green-house and field conditions indicate the existence of a positive correlation between the dosage and the germination. Supporting evidence in this context is available from the investigations of previous workers despite several deviations in their methods of experimentation. Srivastava (1955) treated wheat seed with a variety of pesticidal formulations at various dosages. His findings revealed an increasing decline of germination with a few proprietary formulations containing lindane. The compound Panogen, PL-1 gave 83, 79 and 44 per cent germination at the application rate of 2, 2.5 and 3.5 oz per 100 lb of seed, respectively. Bindra (1960) used certain pesticides for seed dressing of wheat at the rate of 20 and 40 lb per acre. He mentioned that BHC and chlordane 5 per cent dusts especially at the higher rate affected germination, although no figures were given by him. Further evidence to the decline of germination was explored by Patel (1962). He treated wheat seed with BHC 50 per cent w.p. at the rate of 1, 2 and 4 lb per 112 lb of seed. The mean number of plants germinated per plot were found to be 1444, 1003 and 608 with the application rates of 1, 2 and 4 lb, respectively. Allen (1971) observed that some pesticides suitable at a lower rate for seed treatment of wheat, retarded germination at the higher rate. The investigations of Verma _et al._ (1971) on the seed treatment of wheat revealed reducing germination due to the increasing dosages of pesticides. Application of BHC 50 per cent w.p. as dry at the rates ranging from 0.125 to 0.625 kg a.i. per 100 kg seed gave germination varying from 54.8 to 26.4 per cent. Same dosages of this pesticide applied to moistened seed depicted variation in germination from 45.5 to 8.5 per cent. Treatment by aldrin emulsion with dosages ranging from 0.250 to 1.875 kg a.i. allowed germination ranging from 47.8 to 15.3 per cent. The influence of various concentrations of menazon, disulfoton and GS-14254 pesticides on germination of wheat by seed treatment was studied by Dalvi _et al._ (1972). They found that the degree of inhibition of germination depended on the concentration of the chemical. Another study by Verma (1974) on the seed dressing of wheat with dust formulations of BHC and aldrin indicated a decline in germination with the increasing dosages of BHC. Further evidence in this direction with respect to barley seed treatment with various dosages of aldrin is available from the data of Verma _et al._ (1979 b).

From the foregoing discussion it is quite clear that the present observations substantiate the results of earlier workers in-as-much as the differential effects of concentrations of various compounds on germination are concerned.

Effect of formulations:

A pesticide may be applied to the seed in various forms. Different formulations have limitations and advantages with respect to their use for seed treatment. Some potentially phytotoxic insecticides can be applied in powder form without any damage to the seed while a liquid form usually damages the seed (Jeffs and Tuppen, 1978).

The laboratory test with seed treatment on rice by Rolston <u>et al</u>. (1960) revealed that the application rate of 4 oz per bushel with aldrin emulsion reduced the germination but aldrin w.p. at the same dosage did not effect the germination. Bowling (1964) used 50 and 75 per cent w.p. and a liquid formulation of aldrin each with 4 and 8 oz a.i. per 100 kg seed for the treatment of seed rice. The liquid formulation of aldrin at both the rates caused greater reduction in germination and emergence as compared to wettable powders tested at the same rate. For examole, at the dosage of 8 oz the mean total germination in 75 and 50 per cent w.p. and liquid aldrin, was 88.2, 88.5 and 80.1 per cent, respectively. Similarly, at the same dosage the total emergence was 20.8, 20.3, and 17.4 per cent with 75 and 50 per cent w.p. and liquid aldrin, respectively. Another study by Bowling (1965) on seed rice dressings with various formulations indicated that the emergence was lower in aldrin and endosulfan liquid treatments than the same insecticide used as wettable powders.

The application of powders in the present studies was not based on measured amounts of active toxicant as adopted for emulsifiable concentrate treatments. Nevertheless, a few commercially formulated dosages of some pesticidal powders loaded on the seed coincided approximately with the amounts of active toxicants carried by the coatings of emulsifiable concentrates, thus making a comparison possible (Tables 1 and 2). The application of 4 kg chlordane dust with sticker loaded 190.28 g a.i. on wheat seed, gave 83.0 and 74.0 per cent germination in green-house and microplot tests, respectively. On the other side, the dosage of 200 g a.i. of emulsifiable formulation gave 58.0 and 52.0 per cent germination in green-house and microplot tests respectively. Similarly the application of heptachlor dust at the rate of 4 kg with sticker coated 193.82 g a.i. on wheat seed gave 88.1 and 76.7 per cent germination in green-house and field tests, respectively. Whereas the dosage of 200 g a.i. of emulsifiable formulation of heptachlor allowed 68.0 and 52.7 per cent germination. These differences in germination with different formulations of one pesticide under both the conditions of testing are quite discernible and can be safely attributed to the formulation affect. It may be due to the fact that seed to seed distribution is fairly uniform in the application of dusts but in liquid application, formulation of large drops and their adherence on or near the sensitive region of the seed would be damaging to the embryo as evidenced by Jeffs and Griffiths (1978). These authors have argued that cereal seeds are damaged by solutions of phytotoxic substances due to penetration into the seed via scutellum. While the powder formulations of potentially phytotoxic insecticides composed of mixture of active ingredient and innert powder do not penetrate the seed coat in phytotoxic concentrations to cause damage to the seed. Thus the present data support the documentation of the earlier workers that liquid formulations are relatively more toxic than the powder formulations at identical rates of application. However, aldrin and endosulfan which are least phytotoxic to germination did not demonstrate any appreciable difference with comparable dosages on account of formulation in the present findings.

Effect of seed type:

Seed tolerance of various crops to a chemical varies and differences even within the varieties do exist (Brooks and Anderson, 1947; James and Anderson, 1947; Cullinan, 1949; Lange et al., 1949; Srivastava, 1955; Lange, 1959). Barley, rye, wheat and oat seeds were treated with two different dosages of DDT dust by Primost (1950). His results indicated that at higher dosage the adverse effect on germination was negligible in case of barley as compared to other crops. The investigations of Cox and Lilly (19[illegible]2) with several field crops also demonstrated that barley was more tolerant than wheat, and crops of sorghum groups were the most susceptible.

In the present, green-house tests on germination of wheat with dry application of powders at a rate of 2 kg per 100 kg seed revealed adverse effects of wettable powders of BHC, carbaryl and landrin treatments (Table 7). The same rate of application with these pesticides in barley did not reflect any harmful effect on germination (Table 8). Further, the treatments of BHC 5 and 10 per cent dusts, BHC, carbaryl and landrin wettable powders, heptachlor, chlordane and malathion + DDT + BHC dusts and isophenphos + TMTD s.d. when applied at the rate of 4 kg with sticker to wheat seed reduced germination. In case of barley with the same dosage only wettable powders of BHC, carbaryl and landrin affected the germination while the other pesticides did not impair. Additional evidence in this context is available from the data of emulsifiable concentrate treatments given to wheat and barley seeds. Chlordane, chloropyriphos, lindane, phenthoate and phoxim at the rate of 80 g a.i. demonstrated unfavourable effects on the germination of wheat (Table 9), whereas only lindane affected adversely on the germination of barley (Table 10). With the application of 200 g a.i. dosage to wheat seed, it was noticed that all the pesticides except malathion + DDT + BHC inhibited the germination. While in barley aldrin, endosulfan and isophenphos besides, malathion + DDT + BHC treatment did not retard the germination. Similar behaviour of the pesticides on germination was seen in the microplot tests.

Thus the above discussion is ample to draw a corollary that certain pesticides harmful to the germination of wheat at effective dosages are innocuous to barley. The reason of varied susceptibility of wheat and barley seeds may be conveniently attributed to their seed coat, shape, size and structure. Lange (1959) has also mentioned that seed factors play an important part in determining the seed vitality against various pesticidal treatments. Hence, the present results corroborate with the reports of earlier workers.

Effect of testing conditions on germination:

The comparison of germination data obtained under green-house and microplot tests (Tables 7 to 10 and 23 to 26) indicate that the inhibition of germination was more pronounced under microplot field conditions than in the green-house tests. Further examination of soil type, soil moisture, organic matter contents of the soil and the depth of seed placement revealed that except the soil type all the other factors were varied. In microplot field tests the sowing was done at 90 per cent available soil moisture which depleted to nearly 50 per cent during the period of germination. On the other hand, in the green-house tests by frequent watering of pots the moisture was maintained very close to field capacity (100 per cent available soil moisture). As such the moisture level was less in the field tests as compared to green-house tests. The microplot soil had slightly more organic matter (0.13 per cent organic carbon) than the soil used in green-house (0.11 per cent organic carbon). Moreover, in the microplot tests the seed was placed at a depth of about 5 cm while in the green-house test the seedling depth was about 1.5 cm.

Lange (1959) in a review article on seed treatment as a method of control has projected that besides several other factors, soil characteristics and planting practices also enter into the value obtained from seed treatment. Harris (1972) after a critical review of the reports on the factors influencing the effectiveness of soil insecticides concluded that soil type, soil moisture and organic matter content greatly affect the biological activity of the insecticide. In soil, the insecticide is adsorbed on the clay or organic matter of the soil and competes with water for adsorption site. The biological activity of the insecticide is more in lighter soils than heavier soils and is adversely affected with increase in organic matter content of the soil.

In the present studies the soil type was the same under green-house and a microplot field experiments but the organic matter content of microplot soil was slightly higher with relatively less moisture content as compared to the soil of green-house tests. The variation in the organic matter content is so less to have any significant effect on germination. Thus the observed differences in seed germination under the two sets of conditions may well be attributed mainly to variation in soil moisture levels. As exemplified by Harris (1972) the bioactivity of soil applied insecticides is positively correlated with the soil moisture content, whereas in the present green-house studies the soil moisture content was more, the germination was also more showing less inhibitory effect of insecticide on germination. It is, therefore, probable that the soil moisture influences both the bioefficacy of insecticide after incorporation in the soil and the inhibitory effect of insecticide on germination following seed treatment. In the former case, soil moisture increases the toxicity of the insecticide applied into soil but in the latter case, the moisture enhances the process of germination and thereby reduces the phytotoxic effect of the insecticide to the germinating seed. Kirk and Wilson (1960) also observed that following seed treatment of wheat with insecticides, the germination was maximum when adequate soil moisture was maintained by regular watering the pots but the germination was impaired when soil moisture was only slightly above the wilting point. Excess of soil moisture also adversely affected the germination. In addition to soil moisture, the depth at which the seed is placed in the soil also plays an important role in germination. In the microplot tests the per cent germination was less even in the control as the seeds were placed at a deeper level than the seedling depth in the green-house tests.

Phytotoxicity symptoms in wheat and barley seedlings:

Phytotoxicity induced by crude BHC or lindane treatment has frequently been quoted for certain cereals including wheat and barley. The symptoms described by different workers are malformation of plants, atypical growth, shortened and thickened plumule, polyploidy and swelling of root tips, absence of root hairs, necrosis on the rootlets etc. (Kostoff, 1948, 1949; Hocking, 1949; 1950; Jameson and Callan, 1951; Ozkan and Finci, 1974; Zeller and Hauser, 1974). Slight variations in these descriptions of symptoms are probably due to the dosages and the variety of seed used. The observations recorded in these studies on the phytotoxic symptoms of non-emerging seedlings caused by the effective pesticides like BHC and lindane have exhibited resemblance as reported by other workers.

The investigations of Cox and Lilly (1962) have indicated the angular emergence of seedlings from the soil surface and also chlorosis in wheat and barley with the application of higher dosages of aldrin in soil. Subsequent to seed treatment of wheat and barley with emulsifiable concentrates of chlorpyriphos and phoxim as well as with BHC wettable powder treatment, angular emergence of seedlings was noticed in the present findings, though the frequency of occurrence was at a low ebb in barley. As regards the symptom of chlorosis, the dosage of 4 kg wettable powder with sticker of BHC, carbaryl and landrin induced chlorotic streaks or patches in the seedling leaves. Indication of damage to young seedlings by seed dressing of wheat with chlorpyriphos and phoxim is available from the report of Griffiths et al. (1969) and agrees with the observation of the present author. However, these authors have not described the symptoms in detail.

From the above narration it appears that the previous workers have described the phytotoxic symptoms appearing in cereals seedlings caused by BHC or lindane only in some detail. Otherwise only causal or general remark of the phytotoxicity induced by a few other pesticides has been mentioned by other workers.

In the present work, however, phytotoxic symptoms caused by the seed treatment of chlorpyriphos, phenthoate and phoxim (emulsifiable concentrates) and BHC, carbaryl and landrin wettable powders have been illustrated in a categorized manner. To the knowledge of the author , no such detailed and classified symptoms of these pesticides appear to have been explicated by any worker.

Effect on mean emergence period

The mean emergence period exhibits the measured mean time required for the emergence of all seedlings for the treatment. Such a figure is a useful unit to compare the over-all effectiveness of one pesticide from the other. This factor is influenced by the seed, the depth of placement, moisture, temperature and the treatment. In the green-house tests of these studies all the factors were maintained uniform as far as possible except the differences of treatments. Thus the variations in the mean emergence periods were directly affected by the characteristic of the compound and its applied dosage.

Seed treatment of wheat and barley with powder and emulsifiable formulations in the green-house tests revealed variations in the mean emergence period. The present findings in brevity, indicated that certain most effective pesticides at lower dosages delayed the emergence, some were moderately effective and so increased the emergence period with the rise of the dosage, and a few even at the highest tested dosages either caused no delay or affected only mildly. Among the powder treatment, BHC, carbaryl, and landrin wettable powders were mainly responsible for remarkable delay in germination of wheat and barley. Out of the several emulsifiable concentrates tested here, chlorpyriphos, lindane, phenthoate and phoxim treatments caused more delay than the rest of the compounds in both the crops.

The investigations of Lange et al. (1949) on the seed treatment of Fordhook bush bean with lindane demonstrated that mean emergence period increased from 9.91 to 10.27 days with 0.66 and 1.33 oz a.i. dosage per 100 lb seed, respectively, while the untreated seed emerged in 9.76 days. Further evidence to the delay in the mean emergence period of soybeans treated with different pesticides is available from the work of Starks and Lilly (1955 a). All the treatments significantly delayed the emergence in comparison to control. However, relatively less delay but not significantly different from other treatments was observed in aldrin, dieldrin, ortho HL-609 and Benzalax treatments. Lindane was one of the treatments which comparatively caused more delay alongwith a few other pesticides. Another study by Srivastava (1955) with the seed treatment of wheat indicated that among the various pesticides, Panogen, PL-1 (containing 36.6 per cent lindane) caused maximum delay in emergence. The dosage of 2.0, 2.5 and 3.5 oz per 100 lb seed of this pesticide brought about a noticeable delay, showing 7.02, 7.39 and 7.36 mean emergence days, respectively, in comparison to 5.38 days in control. Aldrin, heptachlor and lindane wettable powders and a few other pesticides at any of the tested dosages did not cause pronounced delay in emergence.

From the present data it appears that aldrin, endosulfan and lindane dusts for wheat, and aldrin, BHC 5 per cent, lindane and endosulfan dusts for barley were not unfavourable in respect of mean emergence period even at the highest dosage applied to the seed. The lindane dust being of a very low concentration induced no effect. As regards the emulsifiable treatments on wheat the dosage of 160 g a.i. of aldrin, isophenphos, endosulfan and malathion + DDT + BHC was not adverse to emergence and in case of barley, aldrin applied even at 200 g a.i. produced no conspicuous effect on emergence. Lindane at a dosage of 80 g a.i. for wheat and at 120 g a.i. for barley was harmful out of all the treatments applied at similar dosages. Hence, it is inferred that delayed emergence as observed by earlier workers tallies with the present data but the extent of delay is related to the characteristics of the compound, its dosage and the nature of seed.

Effect on plant growth

Top height:

Top height of the seedling is one of the documented parameters of plant growth to assess the influence of a pesticide. Cullinan (1949) reported the effects on the growth of tomato, cucurbits, corn, potato and peas seedlings when grown in soil treated with DDT, BHC, chlordane and toxaphene. He observed that the lower dosage of 25 lb per acre depressed the growth of some seedlings. The growth was even more depressed with the use of higher concentration of pesticide in the soil, particularly of BHC and chlordane. The findings of Sachan et al. (1967) indicated that the height of wheat plants was significantly curtailed by chlordane dust, whereas aldrin, BHC and dieldrin had no effect. These workers applied the different dosages of insecticide in shallow furrows, placed the seed and then covered with soil.

The top height of wheat and barley seedlings recorded in green-house tests in the present studies demonstrated varied growths due to seed treatment with powder and emulsifiable formulations. Some of the pesticides used in these studies are common to those used by other workers (Cullinan, 1949; Sachan *et al*., 1967). Since, either the crop or seedling growth parameters choosen and the conditions of experimentation of these workers were not identical with this author , only a generalized comparison is possible.

As far as the adverse effects of BHC, chlordane and lindane on plant growth are concerned these results agree with the reports of Cullinan (1949). Sachan *et al*. (1967) have also noted retarding effect on the growth of wheat plants by chlordane dust. All these workers found that the degree of growth suppression increased with the rise of the pesticidal dosages. Similar effects were observed by this author with the seed treatment of BHC and chlordane dusts and lindane and chlordane emulsifiable formulations. However, lindane dust did not reflect such affect due to the very low concentration of the commercial formulation used here. The results of Sachan *et al*. (1967) are contrary to both, the present observations and to the findings of Cullinan (1949) as regards the effect of BHC dust on plant growth. This bizzareness in the results of Sachan *et al*. (1967) is a deviation from the normal trend because even the highest dosage of 30 lb a.i. per acre used by them was not found harmful to the growth of wheat plants. Hence, it is very difficult to interpret the different behaviour of BHC in their trial.

Dry seedling weight:

Seedling weight is another important parameter of plant growth to comprehend the effect of a pesticide (Lange *et al*., 1949; Cox and Lilly, 1952; Starks and Lilly, 1955 a; Srivastava, 1955).

Studies on seed treatment of two varieties of lima beans with lindane applied at the dosages of 0.66 and 1.33 oz a.i. per 100 lb seed were conducted by Lange *et al*. (1949). Their results revealed that the average seedling weights recorded with or without cotyledons from both the treatments were significantly inferior to untreated seedling weights in one of the varieties. It was further noted by them that the average seedling weight was significantly reduced at the higher dosage as compared with the lower dosage in both the varieties. Cox and Lilly (1952) determined the average green weight of wheat and barley seedlings sown in sand treated with 2 to 128 lb a.i. of aldrin and dieldrin per acre. They observed that aldrin and dieldrin suppressed growth with each increase in the application level except a minor deviation from this trend at certain stages of pesticidal levels. However, the effects of dieldrin were slight in comparison to aldrin. Five soybean varieties were treated with an excessive dosage of 4 oz a.i. of BHC (containing 75 per cent gamma isomer content) per bushel seed by Starks and Lilly (1955 a). They observed that the reductions in average seedling weights of all the five varieties were of little practical importance. Srivastava (1955) worked out the ratios of top to root on dry weight basis for wheat seedlings germinated in flats out of doors following seed treatment with different formulations of pesticides. He found that a formulation Panogen, PL-1 (with 36.6 per cent lindane) applied at the rate of 2.0, 2.5 and 3.5 oz per 100 lb of seed gave root-top ratios as 94.0, 88.0 and 69.0, respectively, which were significantly lower than all the treatments with median and highest dosages each significantly lower. Other treatments each with different dosages of aldrin, lindane, heptachlor and 'Seed Guard' were not significantly different in the mean proportional development of roots compared to tops.

The data reported here with regard to the plant growth takes into account the mean dry weight of the seedling. This was considered more appropriate and precise as compared to green weight which is subject to a great variation in view of the different levels of wetness retained on the plants when they are processed through blotter after washing to remove the excess moisture.

The dry weights of wheat and barley seedlings observed in the green-house tests during these studies revealed variations due to seed treatment with powder and emulsifiable formulations (Tables 19 to 22). The apparent reason for such difference is the type of the insecticide and the applied dosage. The increase in the dosage of an effective pesticide enhances the reduction by dry seedling weight. These data further elucidate that a certain pesticidal dosage effective in reducing the weight of wheat seedling is not adverse to barley. For instance, BHC 5 per cent, chlordane, heptachlor, isophenphos + TMTD and malathion + DDT + BHC powders at the dosage of 4 kg with sticker adversely affected the weight of wheat seedlings but not of barley seedlings. Similarly, an emulsifiable concentrate treatment of malathion + DDT + BHC at a dosage of 160 g a.i. adversely affected the weight of wheat seedling while this compound was not unfavourable to barley even at the dosage of 200 g a.i. Thus it is clear that barley seed has a greater tolerance against pesticides than the wheat seed.

A superimposition of the data of both the parameters of plant growth (top height and seedling dry weight) illustrate an interesting feature that certain pesticidal treatments not averse to top height reflected their adverse effect on dry seedling weight (Tables 15, 17, 18 and 19,21,22). This trend is exemplified in wheat with the seed treatment of BHC 10 per cent and chlordane dusts as 2 kg dry, malathion + DDT + BHC dust as 2 kg with sticker and emulsifiable concentrates of isophenphos and malathion + DDT + BHC applied at the rate of 160 g a.i., and in barley with chlordane and chlorpyriphos treatments applied at the rate of 120 g a.i. Contrary to these results in barley the seed treatment with emulsifiable concentrate of phoxim at the rate of 120 g a.i. and endosulfan at the rate of 200 g a.i. adversely affected the top height but not the seedling dry weight. However, the discrepancy of reduced top height but no effect on the dry seedling weight depicted by phoxim and endosulfan treatments might have occurred by compensatory growth in other dimensions of the plants and as such dry seedling weight was not affected while the top height was found to be affected. Keeping in view this argument and the data, the dry seedling weight appears to be a more sensitive and reliable parameter to derive the initial effects of pesticides on plant growth as it takes into account the whole plant instead of a part of it.

From the preceding description it is evident that the methods of treatment, insecticides and their dosages used, the growth parameters choosen, as well as the kind of seed and varieties tested by other workers do not tally with the test material and methodology of this author . Yet, there is a compromise with the present findings in respect of the general trend of increasing adverse effect of effective pesticidal dosages and particularly the harmful behaviour of BHC and lindane on seedling weight (Lange et al., 1949; Starks and Lilly, 1955 a; Srivastava, 1955).

Effect on productive tillering

Effect of pesticides on the tillering of wheat crop has been reported by several workers (Chatterji et al., 1958; Sahni and Butani, 1966; Sachan et al., 1967; Allen, 1971). It appears from the relevant literature that there is no such information on barley crop.

The description of the techniques of the treatments, the insecticides and their dosages tested on wheat by the workers mentioned above do not resemble in one or the other aspect among themselves or with this author . Therefore, a proximate comparison of the present findings with the results of other workers is not possible.

However, a few cues to comprehend the general trend with respect to the effect of some pesticides on tillering can be derived.

The data on the productive tillering of wheat and barley plants following seed treatment with powders and emulsifiable concentrates from the microplot tests in the present findings reveal both the favourable and unfavourable effects of pesticides (Tables 27 to 30). The extent of influence is further associated with the kind of pesticide, its dosage and the seed type. In the present observations, BHC 5 per cent dust applied as 2 kg dry to wheat seed was not harmful to productive tillering but affected only when applied at the rate of 2 or 4 kg with sticker due to increased dosages. BHC 10 per cent dust and 50 per cent wettable powder applied as dry @ 2 kg or with sticker at 2 or 4 kg rate was also unfavourable for the formation of ear-forming tillers. It indicates that BHC formulation of higher concentration, obviously increased the amount of the active ingredient which resulted in more severe effects on ear-bearing tillers. Chatterji <u>et al</u>. (1958) did not notice any adverse effect of BHC dust on tillering of wheat plants. Probably the insecticide applied to the soil was diluted to a level not to induce any deleterious effect. Sahni and Butani (19?6) also did not notice any significant effect on the tillering of wheat plants with the seed treatment of BHC 5 per cent dust or BHC suspension. Since the dosages used by them are not known, it is presumed that they were too low to manifest any effect. In the present studies also dry application of BHC 5 per cent dust was innocuous to earing of wheat due to a very low dosage adhered to the seed. The treatment of aldrin emulsion gave maximum tillering, albeit the difference in number was not significant from the control (Sahni and Butani, 1966). Similar results wer observed in this work with the same pesticide at all the dosages as compared to control and the lowest dosage of 80 g a.i. showed a non-significant numerical increase from the control. Sachan <u>et al</u>. (1967) with aldrin dust at various dosages did not find hampering in the tillering of wheat plants. Application of aldrin dust in the present studies at all the rates did not decline the number of ear-forming tillers in wheat. However, these authors did not find any adverse effect of BHC 10 per cent dust whereas the present observation do not support them. The reason for such deviation may be the differences of the variety of seed and the levels of toxicant remained in contact with the seed. The same authors found that chlordane dust was highly detrimental and no tillering was observed at the dosage level of 50 and 75 lb a.i. per acre but the dosage of 25 lb a.i. per acre gave as good tillering as in control. The results obtained here also show that application of chlordane dust at the rate of 2 kg dry was not averse to productive tillering in comparison to control but the increase in dosage with the application of 2 and 4 kg with sticker inhibited it significantly than the control. Although a reduction was observed by this author but it was not as drastic as reported by Sachan <u>et al</u>. (1967). In the results reported here endosulfan seed treatment with powder formulation at all the dosages and with emulsifiable concentrates up to 160 g a.i. dosage did not restrict the production of ear-bearing tillers in wheat significantly from control, except at the highest dosage of 200 g a.i. While Allen (1971) did not find any decline in the tillering following seed treatment of wheat with endosulfan at the dosages tried by him. Further, a vis-a-vis perusal of data on germination and the productive tillering in the present microplot tests disclosed that some pesticidal seed treatments in wheat and barley crop despite being significantly lower in germination than control produced as good number of productive tillers as in control. This is evident in wheat seed treatment with aldrin at the dosage of 200 g a.i. and in barley with the treatment of carbaryl applied at the rate of 2 kg with sticker and also with lindane at the rate of 80 g a.i. and chlorpyriphos and phenthoate applied at the rate of 120 g a.i. Allen (1971) also reported that despite reduced plant number in methomyl treatment (4 oz per bushel) the tillering of wheat was not affected adversely. Such affect is presumably due to the compensatory phenomenon found in the plants. Thus the findings of Allen (1971) are in partial agreement with the present author in respect of response of endosulfan to tillering and increased tillering with treatments showing less emergence of plants.

Field trials (chemical control of termites)

Seed treatment:

Wheat: Pre-sowing soil application of insecticides especially the aldrin or BHC dust is a general recommendation still followed for the control of termites in most of the agricultural crops (Krishnamurthy and Ramasubbiah, 1962; Reddy, 1962; Sankaran, 1962; Ghosh, 1964; Parihar, 1978; Anonymous, 1981). Moreover, seed dressing of wheat has also been attempted with successful results in India by some earlier workers but the dosages of insecticides used by them were quite high (Bindra, 1960; Patel, 1962; Sahni and Butani, 1966; Verma et al., 1974). As a result of further studies in this direction Verma et al. (1975) and Chahal et al. (1976) observed that much lower dosages of aldrin were quite effective in protecting wheat crop from termite infestation. Similar work on the seed treatment of barley was done by Verma et al. (1979 b) with encouraging results. It is understood that the approach of seed treatment is only meaningful when the quantity of a toxicant is reduced to the extent it remains effective so as to minimize the environmental pollution besides the advantage of low cost and convenience in use.

The results of seed treatment of wheat depicted in Table 35 indicate the significant effectiveness of powders of aldrin 5 per cent @ 1.25 and 2 kg with sticker and also of larvin 75 per cent @ 2 kg with sticker per 100 kg seed for checking termite infestation and increasing the crop yield significantly over the control. Similarly, aldrin emulsifiable concentrate @ 120 g a.i. and endosulfan @ 160 g a.i. per 100 kg seed either used alone or spliced with carboxin treatment are significantly effective in reducing termite damage with higher yields in comparison to control. The compound, BPMC used as dust and in emulsifiable form appears a complete failure as no improvement in checking termite damage and yield over the control was observed.

Seed dressing with aldrin 5 per cent dust @ 20 to 40 lb per acre of wheat seed was advocated by Bindra (1969) which is too high as compared to the recommendation of Verma et al.(1975) who found dry mixing of aldrin

5 per cent dust @ 1.25 kg (62.5 g a.i.) per 100 kg wheat seed enough in improving crop yield over the control against termite attack. In the present findings dry mixing of aldrin 5 per cent dust @ 1.25 kg per 100 kg seed of wheat although better than control (Table 31), the same dosage applied with sticker is significantly superior than dry application. The results of the author are in conformity with the investigations of Verma *et al*. (1975) in as much as the effectiveness of dry application of aldrin over control is concerned. However, in the present work better performance obtained with the use of sticker is due to the higher loading of the applied insecticide while in dry application the adherence is not only initially less but a certain amount of toxicant is further lost due to fall off in tranfer or transit until sowing. Among the powder treatments a new carbamate compound, larvin 75 per cent w.p. applied at the rate of 2 kg with sticker has given promising results over the control. It has not earlier been tested against termites. Therefore, the suitability of this compound worked out in this study against termites is an additional information for practical recommendation.

Seed treatment of wheat with emulsifiable concentrate of aldrin was found to be very effective against termites by Sahni and Butani (1966) and Verma et al. (1974) but the dosages of one litre and 1.25 kg a.i. per hectare, respectively, are high. Another study by Verma et al. (1975) indicated that aldrin @ 125 g a.i. was quite effective against termites in wheat crop. Chahal et al. (1976) tested the dosage of 4 and 8 ml aldrin 30 per cent emulsifiable concentrate per kg seed (equivalent to 120 and 240 ml a.i. per 100 kg seed) and recommended the latter dosage in view of their successful results. The present results support the findings of Verma et al. (1975) as aldrin @ 120 g a.i. gave very good results. In addition to aldrin, the effectiveness of endosulfan emulsifiable concentrate @ 160 g a.i. has been established which was not tested by earlier workers. Moreover, the treatment of aldrin or endosulfan followed by the coating of carboxin reveal their physical compatibility as no significant differences occurred in termite damage or yield as compared with the treatments of aldrin or endosulfan alone. Thus these results substantiate the practical application of combining carboxin with aldrin or endosulfan for seed treatment.

The economics of the treatments is shown in Table 41 where the treatment of larvin wettable powder has been excluded for want of rates as it is in experimental stage of testing. Moreover, carboxin treatment has also been

TABLE 41

Economics of insecticidal seed treatment for the control of termites in wheat crop

Sl. No.	Treatment and dosage per quintal seed	Yield* of wheat (q/ha)	Total** income (₨/ha)	Cost of treat-ment (₨/ha)	Net income over control (₨/ha)
1.	Aldrin 5% dust @ 1.25 kg with sticker	30.12	5421.60	31.88	1654.72
2.	Aldrin 5% dust @ 2 kg with sticker	31.17	5610.60	39.00	1836.60
3.	Aldrin e.c. @ 120 g a.i.	32.06	5770.80	28.00	2007.80
4.	Endosulfan e.c. @ 160 g a.i.	29.97	5394.60	34.00	1659.60
5.	Control	20.75	3735.00	-	-

* Based on data given in Table 35

** Calculated at the rate of ₨. 180.00 per quintal.

avoided to maintain the uniformity in cost of different treatments. The perusal of these data indicate the order of preference based on net income over control as aldrin emulsifiable concentrate @ 120 g a.i. followed by aldrin 5 per cent dust @ 2 kg with sticker, endosulfan @ 160 g a.i. and aldrin 5 per cent dust @ 1.25 kg with sticker per 100 kg seed. Since the yields obtained in these treatments fall in one group of significance, the merit order of net income over control is tentative because any possible numerical fluctuation in yields may occur to alter the sequence of merit.

This trial was conducted in a termite infested field where none of the diseases like smut, bunt and flag-smut appeared. However, at cultivator's field infested with termites the appearance of such diseases is also common for which a blanket recommendation of carboxin seed treatment is imperative to obtain economic control of these disease. It is in this context that the use of carboxin was tested for physical compatability with a few insecticidal treatments.

<u>Barley</u>: The data of seed treatment of barley (Table 36) represent the significant effectiveness of powders of aldrin and heptachlor 5 per cent dusts and larvin 75 per cent w.p. @ 2 kg with sticker per 100 kg seed in preventing termite attack with increased yields

over control. The emulsifiable formulation of aldrin and heptachlor applied @ 120 g a.i. or endosulfan @ 160 g a.i. alone or each of them with carboxin @ 150 g a.i. per 100 kg seed are also significantly effective in retarding the infestation with more yield in comparison to control. The compound, BPMC tested in the form of dust or emulsifiable concentrate remained at par with control as also observed in the wheat seed treatment trial (Table 35).

The results of Verma et al. (1979 b) revealed that dry mixing of aldrin 5 per cent dust to barley seed @ 10 g per kg seed (equivalent to 750 g of aldrin 5 per cent dust with the seed used @ 75 kg per hectare) proved better than control in one season but not in another season. The lack of consistency in their results may be presumed due to the use of a low dosage with all chances of fall off of the dry dust in handling the seed until sowing. The dosage of aldrin dust used by the author is more alongwith the advantage of enhanced loading of the toxicant due to application with sticker. Aldrin emulsifiable concentrate with various dosages was also tested in the seed treatment studies of barley by Verma et al. (1979 b) alongwith aldrin dust treatment in the same trial. They found the dosage of 10 ml aldrin 30 per cent emulsifiable concentrate per kg seed (equivalent to 168.75 ml a.i. per hectare) as the best treatment in the two seasons. However, the dosage of 5 ml aldrin 30 per cent emulsifiable concentrate (equivalent to 112.5 ml a.i. per hectare) was also better than control in one season. The dosage of 120 g a.i. used here is most effective and corroborate to a great extent with the results of Verma et al. (1979 b). Another outcome of the present studies is that besides aldrin formulations, the treatments of heptachlor dust and emulsifiable concentrates of heptachlor and endosulfan have given equally significant results which has offered a new alternative choice of the chemical. Further the treatments of emulsifiable concentrates of aldrin, endosulfan and heptachlor in conjunction of carboxin demonstrated their feasibility for the control of termite infestation without any drawback.

The economics of the treatments presented in Table 42 indicate a maximum net income over control with aldrin emulsifiable concentrate @ 120 g a.i. followed in decreasing order by heptachlor emulsifiable concentrate @ 120 g a.i., endosulfan emulsifiable concentrate @ 160 g a.i., aldrin 5 per cent dust @ 2 kg with sticker and heptachlor 5 per cent dust @ 2 kg with sticker. But this situation is liable to vary because of the fluctuation in yields under field conditions due to the fact that they all fall in the same group of

TABLE 42

Economics of insecticidal seed treatment for the control of termites in barley crop

Sl. No.	Treatment and dosage per quintal seed	Yield* of barley (q/ha)	Total** income (Rs/ha)	Cost of treatment (Rs/ha)	Net income over control (Rs./ha)
1.	Aldrin 5% dust @ 2 kg with sticker	28.93	4050.20	39.00	1025.00
2.	Heptachlor 5% dust @ 2 kg with sticker	28.17	3943.80	38.00	919.60
3.	Aldrin e.c. @ 120 g a.i.	30.55	4277.00	28.00	1262.80
4.	Heptachlor e.c. @ 120 g a.i.	30.19	4226.60	35.00	1205.40
5.	Endosulfan e.c. @ 160 g a.i.	28.97	4055.80	34.00	1035.60
6.	Control	21.33	2986.20	-	-

* Based on data given in Table 36

** Calculated at the rate of Rs 140.00 per quintal significance. The use of carboxin, for protecting the crop from covered or loose smut or barley stripe disease gives a false impression of an additional burden to the cultivator. However, to cover the risk of these commonly occuring diseases a blanket recommendation has to be followed which will automatically reduce the net income over control in the absence of any disease but will go in favour of the cultivator if the disease appears.

Post-sowing treatment with irrigation:

Prophylactic chemical control measures are not followed at times either due to some unavoidable circumstances or merely by negligence which may result in the occurrence of termite infestation in the wheat crop. Further in areas where termite infestation remains within tolerable limits may increase during a favourable season. Under all these conditions it becomes peremtory to adopt control measures in the standing crop. Soil application of persistent chlorinated hydrocarbons alongwith irrigation is usually followed for this purpose. Formerly the application of aldrin 30 per cent emulsifiable concentrate at the rate of 5 litres per hectare was the common recommendation with irrigation (Anonymous, 1972, 1974, 1975). In Rajasthan also the use of aldrin 30 per cent emulsifiable concentrate at the rate of 4 litres or lindane 20 per cent emulsifiable concentrate at the rate of 5 litres per hectare was advocated (Anonymous, 1978). These dosages were experienced to be too high and expensive. Probably with this background, experiments were conducted in Punjab (Sandhu and Sohi, 1977) which revealed that equally good protection to standing wheat crop from termites can be achieved by lower dosages of aldrin with irrigation. During present studies also the results of the initial trial (Table 37) on wheat crop indicated that 400 g a.i. of aldrin, lindane and heptachlor or 600 g a.i. of chlordane per hectare alongwith first irrigation were as good as the higher dosages of these insecticides upto 1000 g a.i. Further assessment of lower dosages of these insecticides during another season confirmed the effectiveness of aldrin, lindane, heptachlor and chlordane. Application of aldrin even at 300 g a.i. was at par with 400 g a.i. of the same insecticide (Table 38).

Differential effectiveness of lower dosages of aldrin has been reported from Haryana (Verma _et al_., 1974) and Punjab (Sandhu and Sohi, 1977). In Punjab even the lowest tried dosage of 0.625 litres of 30 per cent aldrin per hectare (equivalent to 187.5 ml a.i.) was found as effective as 5 litres (equivalent to 1500 ml a.i.) of the same formulation. While in Haryana aldrin at the dosage of 625 g a.i. per hectare (approximately 2 litres of 30 e.c.) was slightly inferior to 1250 g a.i. per hectare dosage (approximately 4 litres of 30 e.c.) on the grain yield basis but did not differ significantly in infestation level. Thus the present results support the investigations of other workers regarding the efficacy of lower dosages of aldrin and further suggest the effectiveness of heptachlor, lindane and chlordane at much lower rates than the conventional rates of recommendation. Moreover, from a comparison of the data of economics (Table 43) of the treatments it is construed that aldrin @ 400 g a.i. is most profitable followed by heptachlor @ 400 g a.i. aldrin @ 300 g a.i., chlordane @ 600 g a.i. and lindane @ 400 g a.i. per hectare. But the differences of net return within these treatments are tentative being worked out on the observed grain yield differences which are non-significant and with the present cost of insecticides which are variable.

Mound treatment:

Application of insecticides for the control of mound-building termites is an easy, effective and economical proposition for the management of termite population especially in endemic areas. Attempts for the destruction of mound-building termites have been made by earlier workers (Beeson, 1941; Roonwal, 1951; Singh and Sharma, 1957; Bindra, 1960; Roonwal and

TABLE 43

Economics of insecticidal treatments alongwith irrigation for the control of termites in wheat crop

Sl. No.	Treatments	Dosage g a.i. per ha	Yield* of wheat (q/ha)	Total** income (Rs/ha)	Cost of treat-ment (Rs./ha)	Net income over control (Rs./ha)
1.	Aldrin	400	29.23	5261.40	108.69	1687.71
2.	Aldrin	300	28.50	5130.00	88.50	1576.50
3.	Chlordane	600	28.95	5211.00	170.00	1576.00
4.	Heptachlor	400	28.93	5207.00	77.00	1665.00
5.	Lindane	400	28.05	5049.00	120.00	1464.00
6.	Control	-	19.25	3465.00	-	-

* Based on data given in Table 38

** Calculated at the rate of Rs. 180.00 per quintal

Chatterjee, 1960). These workers used the dusts, emulsifiable concentrates and mainly wettable powders. Barring, Roonwal and Chatterjee (1960) the early workers, irrespective of the mound volume used despotic quantities of water for drenching the poisons into the termitaria. As pointed out by Roonwal and Chatterjee (1960), both the concentration of the toxicant and the total volume of liquid poured into the termitarium are vitually important for the net performance of this method. During present studies volumes of liquid ranging from 10 to 40 litres per cubic metre of mound volume were tested in a pilot experiment where 30 litres was found to be optimum in the area of experimentation (loamy sand soils).

Of the four chlorinated hydrocarbons evaluated under present studies, aldrin 30 e.c. @ 20 ml and heptachlor 20 e.c. @ 30 ml with 30 litres of water per cubic metre mound volume destructed all the termitaria. Aldrin has earlier been reported to be very effective against several species of Odontotermes (Singh and Sharma, 1957; Bindra, 1950; Roonwal and Chatterjee, 1960). Heptachlor was tested for the first time in the present studies and can be substituted for aldrin, though the latter one has a premium over the former from cost view point. Lindane and chlordane provided only

81.81 and 70.00 per cent control, respectively, and as such can not be recommended. Pouring of phorate granules alone was less effective unless water drenching preceded the granular application for better distribution and effectiveness of the toxicant. Rajagopal and Veeresh (1978) obtained complete control of Odontotermes wallonensis (Wasmann), with phorate granules alone. The differences in the performance as compared with the present results may be attributed to the variations in the composition of the mound soils, humidity and temperature inside the mound in different climatic zones of the country and the species of termites involved in experimentation. Rajagopal and Veeresh (1978) got excellent results with phorate alone at Bangalore where the soils are heavier and the climate is more humid as compared to Jaipur district where the soils are loamy sand and the climate is relatively dry (semi-arid).

Drenching of all the inhabited termitaria in the vicinity of wheat crop at Manoharpur with aldrin emulsion resulted in 49.10 to 70.45 per cent reduction in termite infestation during the next season (Table 40). Total protection in the crop could not be achieved since another subterranean termite, Microtermes obesi was also involved in the field. Sands (1973) also emphasized that direct destruction of the mound-building termite nests has a limited scope in obtaining complete control of the termites especially when some other non-mound building termites are also involved in attacking the crop. In such cases only part of the damage will be checked. The present findings upheld the view experienced by Sands (1973) as this method can not be solely relied upon for the complete protection of the crop from termites. Still the method being easy and cheaper must be exploited even in the existence of some other subterranean species for the regulation of termite population in areas where mound-building termites are responsible for crop damage.

The cost of mound extermination through insecticides ranged between Rs. 1.90 to Rs. 2.40 per cubic metre of mound volume as shown in Table 44. The most effective treatments are emulsions of aldrin and heptachlor where the expenses for destruction per cubic metre mound being Rs. 2.20 and Rs. 2.40, respectively, are not exorbitant in view of the parennial advantage of protection of crop from the ravages of mound inhabiting termites.

TABLE 44

Cost of colony extermination per cubic metre of mound volume

Insecticide	Formulated dosage per cu.m. ml/gr	Rate per lit/kg in Rs.	Cost insecticides Rs	*Of Labour Rs.	Total expenses Rs
Aldrin 30 e.c.	20	70.00	1.40	0.80	2.20
Chlordane 20 e.c.	30	47.00	1.41	0.80	2.21
Heptachlor 20 e.c.	30	56.00	1.68	0.80	2.40
Lindane 20 e.c.	30	50.00	1.50	0.80	2.30
Phorate 10 G	50	22.00	1.10	0.80	1.90

* Two labourers paid Rs. 10.00 per day cover 25 termitaria each day.

CHAPTER VI

S U M M A R Y

Studies with certain pesticides on the adherence to wheat and barley seeds, their effects on germination and plant growth alongwith chemical control of termites were conducted under laboratory, green-house and field conditions mainly at the Agricultural Research Station, Durgapura, Jaipur (Mohan Lal Sukhadia University, Udaipur, Rajasthan) from 1978-79 to 1980-81.

In laboratory test conducted on the relative adherence of thirteen dry pesticidal powders @ 2 kg per 100 kg seed indicated a differential pattern of adherence to wheat and barley seeds. Chlordane 5 per cent dust gave a maximum adherence while landrin 50 per cent wettable powder gave a minimum adherence. Moreover, relatively more adherence was observed on barley as compared to wheat. Further, the coating of the powders was in all cases lower than their rates of application.

The tests of dry adherence with aldrin 5 per cent, BHC 10 per cent and chlordane 5 per cent dusts applied @ 1, 2 and 4 kg per 100 kg seed of wheat and barley demonstrated significant differences in the retention of various pesticidal powders and among the different tried dosages. Although an increased retention was observed with the rise in the application rates of the pesticidal powders, it did not follow a linear pattern.

The probe for the determination of a suitable sticker proved that the use of 2 per cent w/v methyl cellulose solution gave the maximum loading followed by gum arabic and soluable starch for BHC 10 per cent and chlordane 5 per cent dusts at 2 and 4 kg rate of application per 100 kg seed.

In the green-house and microplot tests conducted to study the effect of certain powder and emulsifiable formulations of conventional and new products as seed treatment at various dosages on the germination of wheat and barley, very interesting results were obtained. The germination was found to be influenced by a number of factors viz., specificness of the pesticide, dosage, formulation, seed type and the testing condition.

In case of wheat, BHC, carbaryl and landrin 50 per cent wettable powders applied as 2 kg dry, 2 and 4 kg with sticker adversely affected the germination while aldrin 5 per cent, endosulfan 4 per cent and lindane 0.65 per cent dusts and larvin 75 per cent wettable powder applied at any of the rates tried had no inhibitory effect on germination. In barley, BHC, carbaryl and landrin 50 per cent wettable powder hampered germination when used with sticker due to higher loading of pesticides on the seed. However, remaining pesticides viz., aldrin 5 per cent, BHC 5 and 10 per cent, chlordane 5 per cent, endosulfan 4 per cent, heptachlor 5 per cent, lindane 0.65 per cent, malathion + DDT + BHC (3:3:2) dusts, isophenphos + TMTD (30:10) per cent seed dresser and larvin 75 per cent wettable powder did not exhibit any adverse effect on germination when employed with sticker. Tests with emulsifiable concentrates as seed treatment with wheat revealed that aldrin, endosulfan, isophenphos, malathion + DDT + BHC (25:15:10) at dosages of 80,120 and 160 g a.i. did not impair germination whereas chlordane, chlorpyriphos, lindane, phenthoate and phoxim retarded germination, the extent being directly related with the increasing application rates. The results obtained with barley did not indicate any deleterious effect of the application of most of the tried emulsifiable formulations. Only lindane at the rate of 80 to 200 g a.i. were found to check the germination. The results further revealed that at comparable dosages of powder and emulsifiable formulations, the former ones were relatively safer with regard to germination. It was also elucidated that barley seed was more tolerant than wheat to varying dosages of different tested pesticides.

This study for the first time highlighted the seedling toxicity symptoms accruing from the application of some conventional and a few new powder and emulsifiable formulations to wheat and barley with a precise and detailed description.

In the course of these investigations better germination of wheat and barley following seed treatment was observed in green-house tests as compared to microplot tests with identical treatments possibly due to higher moisture and lesser depth of seed placement.

The observations on the mean emergence period of wheat and barley subsequent to seed treatment by powder and emulsifiable formulations in green house tests revealed the following inferences. Fifty per cent BHC, carbaryl and landrin wettable powders and BHC 10 per cent dust inordinately delayed the emergence of wheat seedlings at 2 kg dry, and 2 and 4 kg with sticker per 100 kg seed dosages. While the application of aldrin 5 per cent, endosulfan 4 per cent and lindane 0.65 per cent dusts at all the dosages did not restrict the mean emergence period. Chemicals like BHC 5 per cent, heptachlor 5 per cent, malathion + DDT + BHC (3:3:2) per cent dusts, isophenphos + TMTD 30:10 per cent seed dresser and larvin 75 per cent wettable powder did not interfere with the emergence at lower dosages, however, the higher dosages of these treatments delayed the emergence. In case of barley, excepting landrin and

BHC wettable powders at all the three dosages and carbaryl at 2 and 4 kg dosages with sticker displayed late emergence, whereas the rest of the pesticidal powders did not come in the way of normal emergence. Seed treatment of wheat and barley with emulsifiable concentrates depicted that in general the period of emergence was observed to be positively correlated with increasing rates of application. In case of wheat, application of aldrin, endosulfan, isophenphos and malathion + DDT + BHC (25:15:10) and in case of barley in addition to these chemicals, heptachlor application upto 160 g a.i. dosage did not appreciably alter the mean emergence period. At 200 g a.i. all the chemicals for wheat and all the chemicals except aldrin for barley delayed the mean emergence period.

The effect of pesticidal seed treatments in wheat and barley on plant growth were assessed using the two parameters (a) seedling top height and (b) seedling dry weight under green-house tests. The results of powder formulations bore significant testimony regarding the safe use of aldrin 5 per cent, endosulfan 4 per cent, lindane 0.65 per cent dusts and larvin 75 per cent wettable powder in case of wheat and aldrin 5 per cent, BHC 5 per cent, chlordane 5 per cent, heptachlor 5 per cent, endosulfan 4 per cent, malathion + DDT + BHC (3:3:2) per cent, lindane 0.65 per cent dusts and larvin 75 per cent wettable powder in barley at all the tested dosages showed no adverse effect on top height. As regards emulsifiable concentrates, aldrin, endosulfan, isophenphos and malathion + DDT + BHC (25:15:10) in concentrations ranging from 80 to 160 g a.i. appeared safer as they did not project any suppression of top height in case of wheat. While in case of barley, aldrin and malathion + DDT + BHC (25:15:10) at the rate of 80 to 200 g a.i. and endosulfan and isophenphos at the rate of 80 to 160 g a.i. were not averse to top growth. These results also bear evidence to the existence of a direct correlation of reduction in top height with the rise in pesticidal concentrations.

Results on the effect of seed treatment with pesticidal powders in wheat with regard to dry seedling weight did not reveal any deterrent affect in treatments where aldrin 5 per cent, endosulfan 4 per cent, lindane 0.65 per cent dusts and larvin 75 per cent wettable powder were used, while the rest of the treatments at one or more dosages reduced the weight. In case of barley, aside these treatments, BHC 5 per cent, malathion + DDT + BHC (3:3:2) per cent dusts and isophenphos + TMTD 30:10 per cent seed dresser treatments also appeared innocuous as they did not alter the seedling dry weight as compared to control. In general, barley was less affected than wheat. Seed treatment of wheat with emulsifiable concentrates demonstrated that aldrin and endosulfan at the application rates ranging from 80 to 160 g a.i. were safer as they did not cause any marked reduction in seedling weight. The highest dosage of 200 g a.i. of all the pesticides caused significant reduction in dry weight. In case of barley, besides aldrin and endosulfan the treatment with malathion + DDT + BHC (25:15:10) was also found safer at all the tested dosages. Lindane application significantly reduced dry seedling weight in barley and lindane and chlorpyriphos in wheat at all the rates.

The observations indicated the order of preference in favour of dry seedling weight as compared to top height, between the two parameters of plant growth used as indicators to assess the toxicity of compounds under green-house tests.

The data on the effect of the powder and emulsifiable formulations of the pesticides used as seed treatment in wheat and barley on the productive tillering of these crops projected interesting findings. In case of wheat, BHC 10 per cent dust, BHC, carbaryl and landrin wettable powders induced remarkable reduction in productive tillering at all the rates of application. In case of barley, however, BHC and landrin wettable powders at 2 kg with sticker and BHC 10 per cent dust, BHC, carbaryl and landrin wettable powders induced remarkable reduction in productive tillering at all the rates of application. In case of barley, however, BHC and landrin wettable powders at 2 kg with sticker and BHC 10 per cent dust, heptachlor and BHC 5 per cent dust, carbaryl and landrin wettable powders resulted in a pronounced reduction of productive tillers. The rest of the treatments did not interfere in the formulation of ear-bearing tillers. Among the emulsifiable concentrates tested on wheat, chlorpyriphos, lindane, phenthoate and phoxim at all the tested dosages prevented the normal productive tillering. While in case of barley only lindane and phoxim at 120 g a.i. and above and chlordane, chlorpyriphos, heptachlor, phenthoate at 160 g a.i. and above debarred the normal productive tillering. Aldrin at all the rates for wheat and aldrin, endosulfan, isophenphos and malathion + DDT + BHC (25:15:10) at all the dosages proved harmless to productive tillering of barley.

In field trials conducted during 1979-80, for the control of termites through seed treatment in wheat and barley included only those pesticides which in earlier microplot tests showed 80 per cent or more germination. Further, on the basis of performance with regard to the parameters of germination, plant and tiller damage as well as the grain yield of the crop, the promising ones were further promoted for the final chemical control tests conducted during 1980-81. In addition, two formulations of a newly procured pesticide BPMC, and carboxin seed dresser alone and with a few emulsifiable concentrates were also evaluated alongwith the other treatments. In wheat crop, all the pesticidal treatments allowed normal germination like control. The treatments with aldrin 5 per cent dust @ 1.25 kg and 2 kg with sticker, aldrin e.c. @ 120 g a.i. without and with carboxin @ 150 g a.i. and endosulfan e.c. @ 150 g a.i. without or with carboxin @ 150 g a.i. were better in checking termite damage and in giving increased yield over control. Whereas, both the formulations of BPMC as well as carboxin given alone did not prove better than control. In case of barley where the lower dosage of aldrin 5 per cent dust @ 1.25 kg with sticker was dropped and three treatments viz., heptachlor 5 per cent dust @ 2 kg with sticker and its emulsifiable formulation @ 120 g a.i. without and with carboxin @ 150 g a.i. were added, the results showed a similar trend as regards germination, damage and yield as obtained in wheat crop. Here all the treatments except BPMC formulations and carboxin alone were significantly superior over control.

Emulsifiable concentrates of aldrin, chlordane, chlorpyriphos, heptachlor and lindane were tested each

@ 400, 600, 800 and 1000 g a.i. per hectare to the growing wheat crop through first irrigation to check termite infestation during 1978-79.

The minimum effective dosages of different insecticides were; 400 g a.i. of aldrin, heptachlor and lindane, 1000 g a.i. of chlordane and 1000 g a.i. of chlorpyriphos. Aldrin @ 1000 g a.i. though better than its lowest tried dosage was dropped in consideration of the low cost-benefit ratio and bioconcentration problem from further testing. Similarly, chlorpyriphos was also deleted as it did not perform well at the lower dosage while use at the highest dosage appeared uneconomical. Further evaluation of the minimum effective dosages alongwith a few more reduced dosages during 1980-81 revealed that application of aldrin @ 400 and 300 g a.i., heptachlor and lindane @ 400 g a.i. and chlordane @ 600 g a.i. through first irrigation were quite effective in withholding termite attack in the growing wheat crop as well as in increasing significantly higher yields than the control.

In the experiments on the destruction of mound inhabiting termite, Odontotermes obesus (Rambur), drenching of aldrin 30 e.c. @ 20 ml and heptachlor 20 e.c. @ 30 ml added to 30 litres of water per cubic metre of mound volume gave the best results. The other effective treatments in decreasing order of efficacy were; water drenching followed by application of phorate 10 G @ 50 grammes; and lindane 20 e.c. @ 30 ml per cubic meter of mound volume. Further, assessment of the destruction of the mounds in the vicinity of wheat fields was found to be an effective proposition for reducing termite incidence in the crop.

CHAPTER VII

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